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THE Festivus

Vol. 51(1)

February 2019



Nipa raft dispersal of mollusks
Calliostomatidae in the Californian Province
Rediscovery of *Retizafra intricata*
Cowries, cones, olives and more

Quarterly Publication of the San Diego Shell Club



THE FESTIVUS

A publication of the San Diego Shell Club

Volume: 51

February 2019

ISSUE 1

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FRONT COVER:

Turridonax takahashii Petuch and Berschauer, new species lying over an artistic rendering of shell color pattern of *T. excelsus*. (Cover artistic credit: Rex Stilwill).

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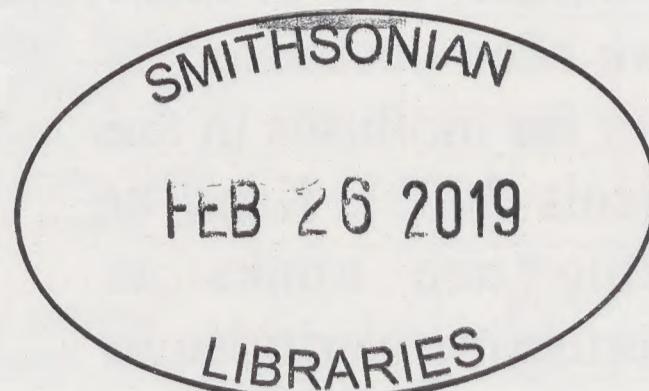
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Notes on molluscs from NW Borneo - Dispersal of molluscs through nipa rafts

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ABSTRACT Nipa rafts regularly form along the NW coast of Borneo, transporting live estuarine molluscs and other invertebrates. Depending on wind direction, currents and tides, they are beached, enter estuaries or float offshore. This paper discusses the potential of such rafts to transport live molluscs to other parts of the same estuary or to other estuaries, thus expanding their range. As nipa palms are known since the Late Cretaceous, transport via nipa rafts may have occurred throughout the Cenozoic.

KEY WORDS Nipa raft, rafting, distribution, estuarine molluscs, Borneo, Malaysia, Brunei

INTRODUCTION

Along the high tide line of most beaches in NW Borneo (Sarawak, Brunei, Sabah) tree trunks or logs are abundant, especially in areas where there is active transport of raw wood, as frequently part of commercial cargoes is lost during transfer. Like other rafting objects, these logs can transport live animals, that often settle on the logs after they reach the sea, especially barnacles (various species) including the goose barnacles (*Lepas anitifera* Linnaeus, 1758). Less frequently nipa rafts wash up onto beaches, and they frequently transport live molluscs and other invertebrates that already lived on the nipa palms before they entered the sea. This poses the question whether this could contribute to the distribution of estuarine molluscs. Rafts of other plants, such as *Papyrus* have been postulated as a possible means of transport for molluscs in the eastern Mediterranean (Mienis 2003). Kano *et al.* (2013) describe floating tree trunks as helping the distribution of estuarine Neritidae in Papua New Guinea. This paper is based on observations by the author made when he lived in the study area (1992-1997) and during later visits, as well as on material collected.

OBSERVATIONS

After storms, nipa rafts comprising one or several nipa palms (*Nypa fruticans* Wurmb, 1779) regularly wash up on the beaches of Sarawak and Brunei, occasionally in large numbers. The rafts transport live palm trees and their seeds, but also animals that live on various parts of these trees. Most of these live on the thick lower part of the leaf petiole and higher up on the leaves. Regularly the thick lower part of the leaf petiole is hollow, providing a well-protected hideout for live animals. Many estuarine animals can survive such trips as they are accustomed to variable salinities. In addition, the nipa trees float upright and therefore their upper parts are not constantly submerged in sea water.

After a northeasterly storm, on the 10th and 11th of August 1995 a large number of nipa rafts washed up on Piasau Beach, Miri, Sarawak (Figure 1). Live estuarine molluscs, barnacles and juvenile goose barnacles (*Lepas anitifera* Linnaeus, 1758) were observed on several rafts. Two of these rafts were closely inspected and the mollusks living on it were recorded (Table 1). The rafts were formed by 3 and 8 palm trees

respectively and each transported 4 to 7 species of brackish water molluscs. For most species the number of live specimens was small. The bivalves and the Neritidae were found on the broad leaf bases and the *Littoraria* species on the leaves themselves. Most oysters were juveniles, the other molluscs were adults. The same storm washed up other floating objects but these had only marine species attached.



Figure 1. Large nipa raft on Piasau Beach August 1995 (no shells were collected from this raft).

The species found on the nipa rafts are typical inhabitants of the middle (brackish) part of the estuary. The author has observed various other species living on nipa palms in the middle part of estuaries including other species of *Littoraria*, *Cerithidea charbonnieri* (Petit de la Saussaye, 1851), *C. quoyii* (Hombron & Jacquinot, 1848) and *Chicoreus capucinus* (Lamarck, 1822). However, the fact that they do not appear on nipa rafts could mean that these species did not live in the estuary from which the nipa floats came, they did not live on those nipa palms that came to form the floats sampled, or they fell off during transport (the latter being likely in the case of *Cerithidea* species as they are less strongly attached as compared to species of *Littoraria* and *Nerita*).

Goose barnacles do not tolerate the brackish water of estuaries – the author never observed them alive in estuaries. They are very common – in huge numbers – on all types of objects floating at sea, as can be noted from

Group	Family	From	Registration number	Species	Raft 1 (8 nipa trees)	Raft 2 (3 nipa trees)	On drum	On driftwood
Bivalves	Ostreidae	E	T0484	<i>Crassostrea rivularis</i> (Gould, 1861)	8	○		○
Bivalves	Anomiidae	E	T0727	<i>Enigmonia aenigmatica</i> (Holten, 1802)	8	○		
Bivalves	Mytilidae	M	T0474	<i>Brachidontes striatulus</i> (Hanley, 1843)				●
Bivalves	Mytilidae	M	T0470	<i>Brachidontes variabilis</i> (Krauss, 1848)				●
Bivalves	Trapeziidae	M	T1679	<i>Neotrapezium sublaevigatum</i> (Lamarck, 1819)			○	
Polyplacophora	Chitonidae	M	T1680	Polyplacophore (unidentified species)			●	
Gastropods	Neritidae	E	T2918	<i>Nerita balteata</i> Reeve, 1855		○		
Gastropods	Neritidae	E	T2917	<i>Neritina cornucopia</i> Benson, 1836	●	○		
Gastropods	Neritidae	E	T1496	<i>Neritodryas dubia</i> (Gmelin, 1791)	●			
Gastropods	Littorinidae	E	T2914	<i>Littoraria conica</i> (Philippi, 1846)	●			
Gastropods	Littorinidae	E	T2916	<i>Littoraria pallescens</i> (Philippi, 1846)			●	
Gastropods	Littorinidae	E	T2915	<i>Littoraria vespacea</i> Reid, 1986	○			
Gastropods	Muricidae	M	T0600	<i>Teguella granulata</i> (Duclos, 1832)				○
Gastropods	Siphonariidae	M	T1663	<i>Siphonaria javanica</i> (Lamarck, 1819)				○
Gastropods	Onchidiidae	E	not collected	<i>Onchidium spec</i>	●			
Barnacles	(Balanoidea)	M	not collected	Barnacle (unidentified species)	8	8		
Barnacles	Lepadidae	M	not collected	<i>Lepas anitifera</i> (Linnaeus, 1758)	8	8		

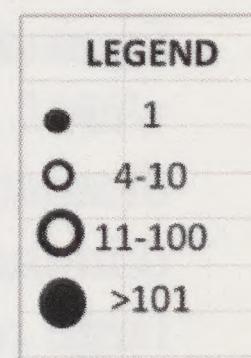


Table 1. Species found on two nipa rafts, a floating drum and drift wood washed up on Piasau Beach, Miri, Sarawak on 11th August 1995. M = species from marine habitat; E = species from estuarine habitat.

beach debris. Their size (on one of the rafts up to 5 mm, on the other up to 8 mm) therefore gives an indication of the minimum time these rafts have spent at sea. The growth rate of goose barnacles recorded by Evans (1958) and MacIntyre (1966) and analysed in Cupul-Magaña *et al.* (2011) and Magni *et al.* (2014) indicates the rafts have been in sea water for at least a week. Based on the strength of water currents in the area, and the time spent at sea, these rafts may have moved over many tens of kilometers, possibly over a hundred kilometers.

Where did these rafts come from?

This section focuses on the possible origin of the rafts studied. Even though no firm conclusion is reached, there are strong indications that nipa rafts can transport estuarine species over substantial distances.

Where estuaries have sufficient freshwater swamp behind them, estuaries are generally lined by mangrove vegetation. In the more saline parts of the estuary, the mangroves are dominated by mangrove trees with stilt roots or with pneumatophores that protect the sediment from erosion. Where there is strong freshwater were broken off during floods forming dramatic influx the mangrove communities are dominated by nipa palms. These typically form large clusters along the edge of distributary channels or the bay, which exposes them to strong waves and currents. The author observed blocks of nipa vegetation becoming detached and forming rafts along the Seria river (Brunei, October 2006), a slow process during normal tides: a virtually disconnected raft stayed in position for at least 4 days during calm weather. On the other hand, once disconnected rafts can move quickly: within a few minutes a raft on the Tutong river (Brunei, November 2013) moved tens of meters on the strong ebb current in the main river channel. Large stands of nipa

palms were broken off during floods forming clumps on the Seria beach, Brunei (McIlroy & Obendrauf 2008: 57 and Figure 2). Rafts can also be formed where erosion exposes nipa vegetation directly to the sea as observed S of Bakam, Sarawak in 1997 (see Figure 8).



Figure 2. A large number of nipa rafts on the beach. Panaga beach near Seria, Brunei. (Photo courtesy of Roger McIlroy).

When a large number of rafts are beached it appears likely they were detached from one of the larger estuaries, as longer stretches of nipa will be exposed in such areas, whereas in smaller or narrower estuaries the currents and waves are insufficiently strong to form numerous rafts in a single event. It is impossible to determine with certainty from which estuary the rafts were detached, but some information is available. As the storm blew from the NE, it is most likely the rafts came from that direction. The largest estuaries with nipa are those of the Baram river in Sarawak and the Seria and Tutong rivers plus Brunei Bay in Brunei (Figure 3). Locations further away in Sabah are considered too remote. Based on simulations (Alas & Bentillo 1992), during the NE monsoon it would take an oil slick from the Champion field 3-4 days to reach the coast near Seria (about 80 km); nipa rafts would travel a similar distance.

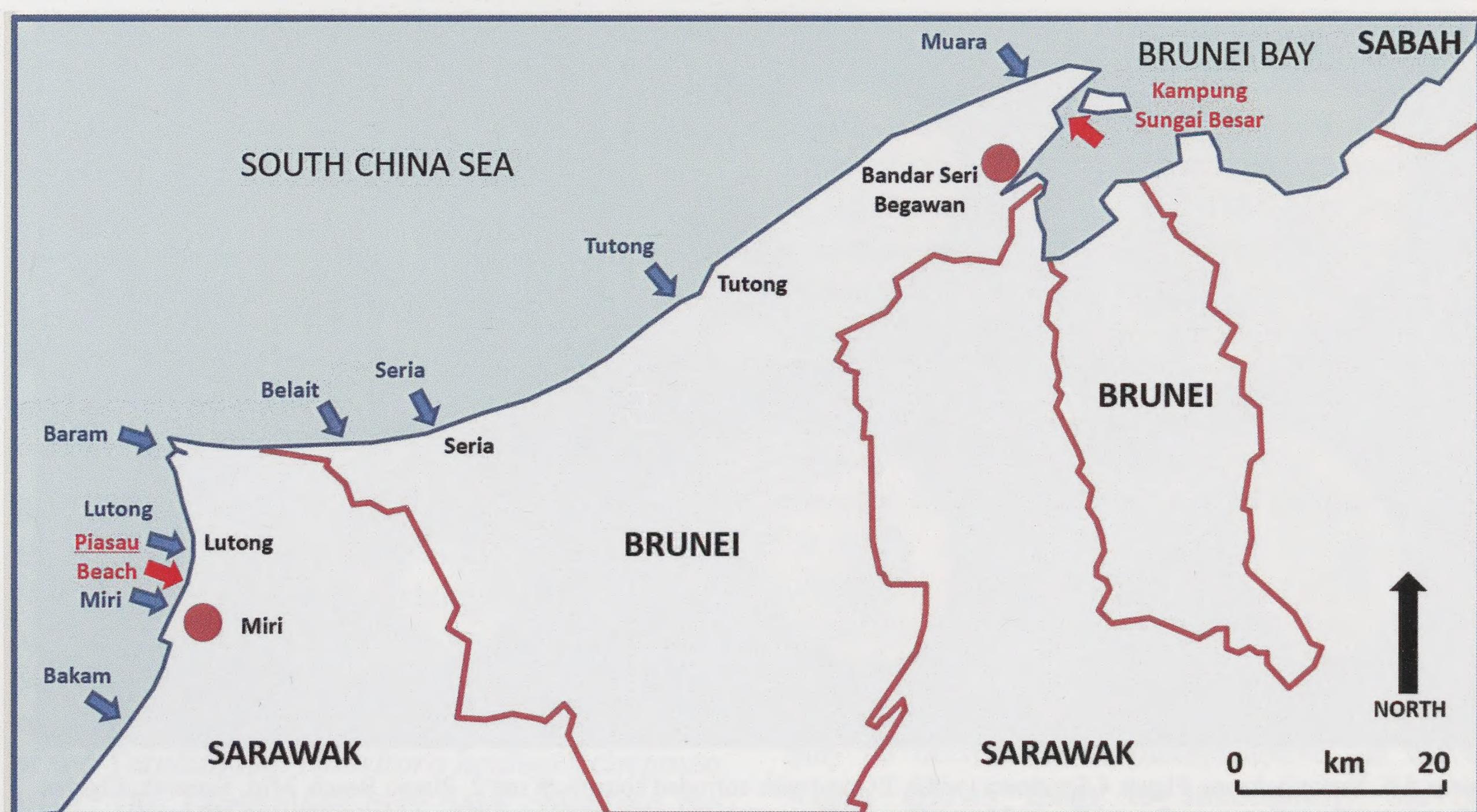


Figure 3. Northwest Coast of Borneo. Selected cities and villages are indicated in black; estuaries sampled are indicated with blue arrows; the possible origin and end point of the nipa rafts are indicated with red arrows.

An indication is provided by one of the gastropod species found on the rafts. *Nerita balteata* Reeve, 1855 occurs in many estuaries, but in the 1990's not in those near Piasau beach. The nearest occurrences of *N. balteata* are from the Bakam river (~40 km to the SW) and the Seria river (~40 km to the NE). Only the specimens from Brunei Bay (Kampong Sungai Besar, Muara, author's collection) are similar to those collected from the rafts (Figures 4-6), having their thick and dark spiral ribs dissolved (except near the aperture), thus exposing the underlying yellowish layer. Such dissolution of sculpture and early whorls (due to acidity of the water) is frequent in freshwater shells in NW Borneo. Also, the shells of *Neritina cornucopiae* Benson, 1836 from the rafts have dissolution spots (Figure 7). The rafts, therefore, may have originated in Brunei Bay (~150 km to the NE of Piasau Beach), but at least came from an estuary further than 40 km away.

Discussion - rafts and other floating objects

Nipa rafts are not unique. Live animals have also been collected from numerous other rafting objects that can transport them over long distances (e.g. brown kelp distributing Trochidae from Australia to Peru (DeVries 2007: 117), pumice dispersing more than 80 species over >5000 km in 7-8 months (Bryan *et al.* 2012)). Typically, these studies focus on the dispersal of marine organisms, albeit Gillespie *et al.* 2012 give an overview for terrestrial and littoral organisms. Much less is known about the transport of brackish water species, therefore the paper by Kano *et al.* (2013) is welcomed. It focuses on the role of drift wood in the dispersal of several species of estuarine Neritidae.

Rafting on floating vegetation may be an important mechanism for the dispersal, gene flow and geographic range expansion of benthic



Figures 4-6. *Nerita balteata*. Figure 4 Specimen (width 29 mm) with corroded apex from raft 2, Piasau Beach, Miri, Sarawak; Figures 5-6 Specimens from Kampong Sungai Besar, Muara, Brunei; Figure 5 Specimen with corroded apex (width 28 mm); Figure 6 Specimen with corrosion limited to the early whorls (width 28 mm).

brackish animals, as suggested for the mangrove species of the littorinid snail genus *Littoraria* (see Reid 1986: p. 66). Okutani (2000: p. 869) reports the mussel *Adipicola longissima* (Thiele & Jaeckel, 1932) as specifically known from sunken nipa, at depth of 500-1800 m from the area between Indonesia and Japan.

In the study area, drift wood is the most abundant form of raft, mostly originating from logging as can be judged from the straight edges of the logs and the clear markings. Most of the rafting logs end up along the high tide line of beaches and lower (but substantial) numbers along the high tide line in estuaries. Finding more than ten logs in a small estuary (like that of the Lutong river N of Miri, Sarawak) is not exceptional. It appears that rafts frequently enter estuaries, which can be explained by the strong currents that form during rising tides.

Some of the drift wood found on the beach has rafted long enough to be overgrown with barnacles, goose barnacles, oysters and/or other molluscs including marine representatives of the Neritidae and to be drilled by marine species of the bivalve family Teredinidae – but all beached logs observed by the author comprised only marine molluscs. They are ideal for transporting marine animals as they lie horizontally in the water with most of the trunk submerged and the remainder regularly splashed by waves.

Some of the drift wood found in estuaries is inhabited by molluscs. Marine species might survive briefly in estuaries but cannot really thrive there. The author has not seen any evidence of marine species alive on drift wood in estuaries. On the other hand, he found the brackish water species *Bactrnochophorus thoracites* (Gould, 1856) [a wood boring bivalve of the family Teredinidae] in logs along the high tide line in several estuaries in NW



Figure 7. *Neritina cornucopiae* shells showing dissolution. From raft 1, Piasau Beach, Miri, Sarawak (width 22 mm).

Borneo. Several adults at the Lutong river estuary and another estuary 6 km further North, North of Miri, Sarawak, Malaysia and a single juvenile at Kampong Pohon Batu, Labuan, Sabah, Malaysia. At the first locality, they were accompanied by another brackish water species of the Teredinidae: *Nausitora hedleyi* Schepman, 1919. The Teredinidae may have colonised the logs once they entered the estuaries, but they can survive in water of different salinity as they can close the tube they form with their pallets. Turner (1966: 52-56) already indicated rafting as an important means of dispersal for some species of the Teredinidae, including the brackish water species *Nausitora dunlopei* Wright, 1864. The larvae of that species settle on drift wood, some of which may float out of the estuary, pass time at open sea before they reach other estuaries. Upon reaching brackish water the adults are likely to spawn (Turner, 1966: p. 52). During periods of rising tides, the incoming tides typically lift drift wood and displace it further into the estuary until it reaches areas that are very infrequently flooded and where the Teredinidae eventually die (author's observation). Such logs start rotting and become the preferred habitat of the terrestrial gastropod *Ellobium aurisjudae* (Linnaeus, 1758). (Raven & Vermeulen 2007).

Drift wood therefore demonstrates how large rafting objects can transport live marine and

estuarine animals, although the author has no evidence of other species than the Teredinidae that live inside the wood reaching estuaries. The only record of other estuarine species using drift wood is Kano *et al.* (2013) who observed estuarine Neritidae on drift wood in Papua New Guinea and Vanuatu. On the other hand, nipa palms are ideally positioned to transport a wider range of live estuarine species. Such palms are frequently found in the middle part of the estuary and typically form the vegetation directly lining the water, which causes them to be easily detached. The author has frequently observed such rafts moving around within estuaries before they are expelled to the sea. Nipa rafts float with the trees in natural (upright) position, which means the live estuarine species may be decimeters to meters above the waves which allows them to successfully survive during their trip. Nipa rafts thus perform a similar role to *Papyrus* rafts in the Mediterranean which transport freshwater species (Mienis 2003).

Estuaries themselves have a very discontinuous distribution. In the area studied (northern Sarawak, Brunei, southern Sabah), each estuary has a different subset of the species present. Typically, the larger and more open estuaries offer a wider range in habitats comprising a larger number of species. Rafts may play a role in the exchange of species between estuaries.

Transport of live animals on rafts can facilitate the distribution of species within an estuary – as the raft moves up and down with the tides it can get stuck anywhere on its voyage - or to other estuaries (see also Kano *et al.* 2013). River-dominated estuaries (salt wedge estuaries, e.g. that of the Baram river) offer the most challenges to the entrance of nipa rafts as they are typically narrow and have a continuous seaward flow of fresh water at their surface. Most estuaries in NW Borneo are wider with

stronger tidal influence and have partially mixed or vertically homogeneous water circulation facilitating the entrance of rafts after which tides and wind push them towards the high-tide line on the river banks or marshes.

Will a single specimen reaching an estuary be sufficient? Some species will require at least a representative of each sex to reproduce. However, a single female neritid may keep laying fertilized eggs with sperm from previous mating that are retained for a long time in the spermatophore sac and/or seminal receptacle (Kano *et al.* 2013: p. 380, quoting Andrews 1937). Previously laid egg capsules could easily be transported on these trunks - they hatch after 2-3 weeks with veliger larvae being released (as observed by Govindan & Natarajan 1972 in similar Indian species).

This dispersal method is only suitable for species living on nipa palms, not those living in other parts of the estuary or on other substrates (e.g. the many species living in or on mud). On the other hand, many of the species found on the raft have planktotrophic larvae, which offers them an alternative dispersal method. The rafts therefore are just one of several possible dispersal methods.

Nipa rafts and the geological record

It is likely that nipa floats played a similar role in distributing species throughout the Cainozoic. Mangrove pollen are known from the Late Cretaceous, whereas fossilized nipa nuts are known from the Eocene of Europe, North & South America and Tasmania (e.g. Gee 2001). Especially during intervals with rapid changes in sea level rafts may have helped dispersal. For example, between 12,000-6,000 Before Present time ("BP") sea levels rose from about -120 m to current levels, as a result of which, all along the NW Borneo coast rivers were forced to

retreat and estuaries constantly changed, disappeared or new estuaries were formed depending on the existing topography. Even today such changes continue, albeit on a much-reduced scale (Figure 8). Throughout this period nipa rafts may have helped species settle in the other parts of estuaries or in other estuaries.



Figure 8. Due to the retreating coastline 2 km south of Bakam (northern Sarawak, Malaysia) the beach has reached the nipa palms of a small estuary and is breaking away nipa rafts (March 1993). This nipa forest has now fully disappeared (satellite images - Google Maps) as has also happened with other nipa occurrences between Bakam and Tanjung Batu (20 km further SW).

RESULTS

Nipa rafts are common and as the plants stay upright, the rafts are well-suited for transporting living estuarine molluscs. The rafts can transport molluscs to other estuaries or other parts within the same estuary and thus provide an alternative dispersal mode for estuarine species. Additionally, nipa rafts may float to open sea (through which estuarine shells could end up in fully marine thanatocoenoses) and eventually sink (providing a substrate for other species). Nipa rafts may have played this role throughout the Cainozoic.

ACKNOWLEDGEMENTS

The author is indebted to Prof. Dr. Edi Gittenberger and Prof. Dr. Geerat Vermeij who inspired him to publish this article. The comments of an anonymous reviewer improved the manuscript. Roger McIlroy provided several photographs of nipa rafts in Brunei.

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***Calliostoma* and *Akoya* of the Californian Marine Province (Gastropoda: Calliostomatidae)**

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ABSTRACT Fifteen species of Calliostomatidae are known to occur in the Californian marine province. Biological observations *in situ* on shallow water species indicates they are primarily carnivores, feeding on sessile organisms such as sponge, bryozoan, hydrozoa, diatoms and various Cnidaria. Adult variation, distribution, depth, and habitat are discussed and a summary of distribution records are provided for unique species. Analysis of shell morphology indicates *Akoya titanium* is a synonymy of *A. platinum*. A review of museum material also suggests that *C. splendens* appears to be correctly placed as a synonym of *C. supragranosm*. A new species of *Calliostoma* from the most southern portion of the Californian marine province is described and illustrated.

KEY WORDS *Calliostoma*, *Akoya*, *Callisotoma guerreroensis*, Calliostomatidae, Californian Marine Province, diet, distribution.

INTRODUCTION

The Calliostomatidae constitutes a unique group of snails which had long been placed in the family Trochidae (Rafinesque, 1815). Although the family Calliostomatidae are quite diverse, only two genera are known from the Californian Marine Province (MP), *Akoya* (Habe, 1961) and *Calliostoma* (Swainson, 1840). Both have a closed umbilicus and tend to be pyramidal in shape with thin spiral ridges called threads (lirae) that may be smooth or beaded; larger threads are called cords. The shell of *Calliostoma annulatum* (Lightfoot, 1786) has beaded threads and cords (Figure 1), while the cords of *Calliostoma canaliculatum* (Lightfoot, 1786) are not beaded giving the texture of the shell a different feel and appearance (Figure 2).

Within the Californian MP, there are at least 15 species of Calliostomatidae, approximately two-thirds of which are shared with the Oregonian MP to the north, and one-third with the Panamic MP to the south. *Calliostoma turbinum* (Dall,

1896) is the only species thought to be endemic to the Californian MP. Because many of the same species occur in multiple marine provinces, relevant observations from both the Oregonian and Panamic MP are included as appropriate.

The Californian MP extends from Point Conception, Santa Barbara County, California south to the area of Bahia Asuncion, Baja California Sur, Mexico. The cool waters of the Oregonian MP lay mostly north of Point Conception. The transition zone between the Oregonian and Californian MP is relatively narrow while, the transition zone between the Californian and Panamic MP is very broad.

North of Point Conception, the authors have found *C. canaliculatum*, *C. ligatum* (Gould, 1849), *C. gloriosum* (Dall, 1871), *C. gemmulatum* (Carpenter, 1864), and *C. tricolor* (Gabb, 1865), in rocky intertidal habitat during minus tides; occasionally *C. annulatum* is also found there. In southern California, summer surface water temperatures are 74° to 80° F, as a

result, these and other cool water *Calliostoma* from the Oregonian MP are typically found only subtidally, and often below the thermocline. Approximately 25% of the Calliostomatidae species in the Californian MP are most frequently found at depths greater than 90 m.

Abbreviations

(ANSP)	Academy of Natural Sciences, Philadelphia, PA
(SIO)	Benthic Invertebrate collection, Scripps Institute of Oceanography, CA
(CM)	Carnegie Museum, Pittsburgh, PA
(CSDOMP)	City of San Diego Ocean Monitoring Program, CA
(LACM)	Natural History Museum of Los Angeles County, CA
(SBMNH)	Santa Barbara Museum of Natural History, CA
(SDMNH)	San Diego Museum of Natural History, CA
(USNM)	United States National Museum, Smithsonian, Washington D.C.
(BCS)	Baja California Sur, Mexico
(MP)	Marine Province
(PNW)	Post Nuclear Whorl
RV	Research Vessel

METHODS

In addition to visiting the above museums, private collections in southern California were examined.

To address the identity of the three large white deep water *Akoya*, the holotypes of *Akoya platinum* (Dall, 1890), *A. titanium* (McLean, 1984) and *A. bernardi* (McLean, 1984) were examined and the descriptions reviewed. A table was made of characters used to score each shell: (1) peripheral cord (weak vs. strong), (2) threaded above the peripheral cord on final whorl (no, weak, strong), (3) threads above the

peripheral cord beaded (no, weak, strong), (4) post nuclear whorl 1 (PNW) with crenulation (yes, no), (5) shoulder immediately below suture tabulated (no, weak, strongly) and, (6) shoulder cord of body whorl beaded (no, weak, strongly). Shell shape, texture and luster were found to be inconsistent characters and therefore were not utilized as characteristics for determining identity. Each shell was evaluated for these six characteristics and the data entered into a spread sheet.

Once evaluated the shell was scored based on its similarity to the type series of each taxa. For example, if the specific character was strongly defined on the type, but absent on the shell examined the score was zero, if weakly developed it received a half point, and if similar to the type it received 1 point. Shells with characters close to the type could score 4.5-6 points (representing an overall character similarity of 75 - 100%), while dissimilar shells would score lower. Characters were evenly weighted. The data was then sorted in any number of ways to examine character associations, and the similarity of each shell to the types. Shells were considered to be intermediate if none of the 3 scoring opportunities met or exceeded 75% similarity.

DIET AND REPRODUCTION

The diet of only a few west coast calliostomids has been confirmed by field observation and gut analysis. *Calliostoma* are omnivorous with a strong preference for sessile invertebrates and a few species may consume kelp. The diet undoubtedly varies by location and opportunity. In Washington, Perron (1975) found that the gut of *C. annulatum* contained sponge spicules and both *C. annulatum* and *C. variegatum* (Carpenter, 1864) fed *in situ* on various species of hydroids, while *C. ligatum* fed mostly on diatoms. In captivity, he reported *C. ligatum*

also consumed hydroids while *C. annulatum* fed on sea pens, bryozoans, anemones, nudibranch eggs, and dead animal material. Harbo (2007) illustrated *C. variegatum* feeding on hydrocoral *Stylaster californicus* (Verrill, 1866). In Alaska, Stone, *et al.* (2014) photographed *Akoya platinum* (Dall, 1890) feeding on the gorgonian *Primnoa pacifica* (Kinoshita, 1907) at 200 m. Deep water species are probably both opportunistic predators and scavengers.

Three species are periodically associated with kelp fronds. In central California, Lowry, *et. al.* (1974) reported *C. annulatum*, *C. canaliculatum* and *C. ligatum* were found predominately on the reproductive growth of the brown kelp *Cystoseira* sp. in the spring and summer, but during the fall *C. annulatum* and *C. canaliculatum* moved to *Macrocystis* sp. while *C. ligatum* moved to rock substrate. They also discussed the vertical movement of these species on kelp stipe. These observations have been interpreted by some that they were consuming the kelp but that is not stated in the paper. R.H. Morris *et al.* (1990) reported *C. annulatum* fed on the anemone *Corynactis californica* (Carlgren, 1936), which occur on hard substrate, and both *C. annulatum* and *C. ligatum* fed to some extent on the fronds of brown kelp such as *Macrocystis pyrifera* (L) and *Cystoseira* sp. Both of these *Calliostoma* have a digestive enzyme laminarinase, that assists with the breakdown of the main carbohydrate in kelp, Morris, *et al.* (1990).

In southern California, *C. annulatum* and *C. canaliculatum* have been observed grazing on microfauna that live on the kelp fronds. In Mission Bay, *C. gloriosum* was observed feeding on sponge, and *C. suprngranosum* (Carpenter, 1864) fed on bryozoans. Keen (1975) noted that in captivity when natural food sources are not provided that *Calliostoma* may attack a wide variety of soft bodied

invertebrates that are dead or alive, and reported *Calliostoma* feeding on dead fish *in situ*. The varied diet has likely contributed to their success in a wide range of habitats and depths.

The reproductive biology of the North Eastern Pacific *Calliostoma* is virtually unknown. Hunt (1980) reported a female *C. ligatum* released approximately 3,000 small spherical green eggs during the course of just over 2 hours. Ten to 12 eggs were contained in each clear mucus sheath, which settled to the bottom of the container. Holyoak (1988) followed up on this observation with a detailed account of spawning and larval development. He reported a greater number of eggs contained in gelatinous strands, which were fertilized by sperm released into the same water column. In captivity, veligers emerged from eggs after 6 days (maintained at 10°C) and remained in the water column for 3-4 days, after day 4 larvae alternately crawl and swim before metamorphosing on day 12. Spawning occurred frequently in captivity and slight increases in water temperature may have been the trigger. For additional details on fertilization and development, review the work of Holyoak 1988. The reproductive biology of *Tegula funebralis* (Adams, 1855) from California was described in detail by Moran (1997) and many aspects are similar to that described by Holyoak (1988) for *C. ligatum*.

DISCUSSION

Depth and distribution records are provided as general guidance. The Pacific coast of Baja California, Mexico has not been sampled as extensively as southern California. It is likely that many deep-water species, not yet reported, occur at appropriate depth and habitat in Baja California. Seasonal and long-term cyclical events, such as El Niño, cause notable fluctuations in oceanic conditions which may affect species abundance and short-term shifts

in distribution. Having reviewed material from Alaska to Central America, other than size, geographic variants have been minimal.

For each species the author, date, location of the holotype and type locality are provided if designated. With the exception of the new species described in this paper, notes regarding shell characteristics are provided for general guidance. Additional location and depth records are given for species that are seldomly found. The distribution and depth range of common species is included but multiple locations are not cited.

Comments regarding relative abundance of species in collections may not reflect the extent of natural populations. Many of the deeper water species appear numerous at 100 meters or more, but are uncommon to rare in collections because (1) the need for a sizable boat, (2) the equipment required to collect at that depth, (3) regulations and required permits to conduct such sampling, and (4) restricted access and collecting prohibitions in some countries.

One specimen of *C. antonii* (Koch in Philippe, 1843) in the USNM has San Diego, California data. No additional specimens from California or the length of Baja California Peninsula have been reported. The species is known from mid Central America, south to Peru (McLean, 1971), and therefore not included as a member of the Californian Marine Province.

Other recent publications regarding west coast Calliostomatidae include Berschauer & Clark (2018) who illustrate *Calliostoma* found in southern California and Tuskes (in press) who reviewed and illustrated all genera and species of Calliostomatidae from the Northeastern Pacific (Bering Sea to central Baja California, Mexico) and the dated but classic works of Oldroyd, 1927, and McLean, 1978.

SPECIES ACCOUNTS

Calliostoma Swainson, 1840

Type Species *Trochus conulus* (Linnaeus, 1758).

1. *Calliostoma annulatum* (Lightfoot, 1786)

[Figure 1]. Holotype and type locality not designated.

Shell height. 25-35 mm. The shell of this distinctive species is gold to yellow with a purple ring at the periphery and above the suture. The spiral threads are brown with yellow to gold beads and the whorls are slightly convex. Both the yellow and purple colors of the shell may fade over time. The animal is golden yellow with dark brown to black spots.

Calliostoma annulatum is more frequently observed in the northern Channel Islands off Santa Barbara. Further north, in the Oregonian MP, it may be found in rocky habitat during minus tides, and has been collected at 190 m. In the Californian MP, this species occurs subtidal on kelp and hard surfaces. On calm sunny days, this species is occasionally found on kelp fronds that have reached the surface of the water.

Range. East of Afognak Island, Gulf of Alaska, to the coast of Alaska (Clark 2018). Prior records were from Forrester Island and Bear Bay, Alaska south to Isla San Geronimo off the west coast of northern Baja California, Mexico. Scarce south of Santa Barbara, California.

Calliostoma bernardi McLean, 1984

see *Akoya platinum* # 15

2. *Calliostoma canaliculatum* (Lightfoot, 1786)

[Figure 2]. Holotype and type locality not designated.

Shell height. 23-35 mm, large specimens to 45 mm. This is the largest species in both the Oregonian and Californian marine provinces.

The shell is off-white to light brown with prominent smooth spiral cords and occasionally darker brown flammules. The whorls are relatively flat.

Although usually found in water less than 30 m deep, *C. canaliculatum* does occur to depths of 80-90 m. In central California, we have observed small adults of *C. canaliculatum* living in the rocky intertidal surf zone north of Shell Beach (San Luis Obispo County, CA). *Calliostoma canaliculatum* is found infrequently on the surface fronds of *Macrocystic porphyra* off San Diego and tend to be larger than those we have found intertidally in central California.

Range. Sitka, southern Alaska, south to Isla San Benito, Baja California, Mexico. Locally common north of Point Conception. Scarce in the Californian MP.

3. *Calliostoma eximium* (Reeve, 1842)
[Figures 3a-b]. Holotype: Museum
Cuming: Payanum, Panama Bay,
Panama, muddy sand, 10 fm. (18.3 m).

Shell height. 20-25 mm, large specimens to 32 mm, shell sturdy, gray to tan. The periphery of each whorl is vertical. As a result, when the next whorl is added, the area above the suture is nearly vertical, and then becomes distinctly concaved, giving the whorls a stepped appearance. Some individuals have numerous dark spots with occasional dark brown dashes on the threads forming broken lines, while others have bold flammules especially on the final whorl. The two specimens illustrated represent the expected variation in both color and shape.

Live specimens have been collected on sand, muddy sand, and rubble from the low intertidal zone to at least 75 m, but most are taken in less

than 37 m of water. When described, Reeve (1842) only cited Panama, much later Dall (1921) and Oldroyd (1927) listed Santa Catalina Island off southern California as the northern extent of the range. Subsequent authors have not listed it as a California species (Keep 1947, McLean 1971, Abbot 1974, Keen 1975). We found one specimen in the SDMNH of *C. eximium* mixed with a series of *C. gloriosum*. The file card that matched the number on the shell did not provide a date or collector and is for *C. tricolor* from La Jolla. Considering the discrepancies with the data, it is not treated as a valid record. The species is well documented in the most southern portion of the Californian MP.

Range. Isla Cedros, Baja, California, Laguna Scammons and Laguna San Ignacio, south to Bahia Magdalena, Baja Sur, Mexico and from Punta Penasco, Sonora in the upper Gulf of California south to Caelata La Cruz, Peru, with the last record from Shasky (1997). Uncommon.

4. *Calliostoma gemmulatum* Carpenter, 1864
[Figure 4]. Holotype: USNM 16261.
San Pedro, California.

Shell height. 13-17 mm, large specimens to 21 mm. The shell is gray to gray-brown with light brown to dark gray-green blotches. There are two prominent beaded cords one on the shoulder the other at the periphery. The peripheral cords are above the suture on past whorls, lesser cords are strongly beaded, while threads are variable.

Based on museum collections, in the past this species has been locally common in southern California. It is found subtidally to at least 25 m in rock habitat on the open coast and protected areas. Crabbed specimens in good condition may be found intertidally.

Range. The species occurs as far north as San Simeon (records from specimen at CM) in San Luis Obispo County, California and has been a dependable find during minus tides at Cayucos. There are numerous records for southern California and northern Baja with the most southern record currently known from Punta Pequena, San Juanico, Baja California Sur, Mexico. Uncommon in Californian MP.

5. *Calliostoma gloriosum* Dall, 1871
 [Figures 5a-c]. Holotype: USNM 206134.
 Monterey Bay, California.

Shell height. 22-35 mm, shell sturdy. The base color of the shell is either dull orange or tan, with one or two rows of darker brown blotches or flammules on the whorls, occasionally with a light tan line between the blotches. The extent of dark blotches and/or flammules are variable. Some dull orange shells from Morro Bay, California have a light rose cast and Johnathan Centoni has collected some that are more intensely colored in Monterey Bay, California.

In the Oregonian MP, the species has been collected intertidally/subtidally to 100 m and is locally common. In southern California, this species is associated with rock substrate at depths of 5 m in protected areas, to greater than 90 m (CSDOMP) off shore.

Range. San Francisco south through southern California and northern Baja California, to Isla San Benito, Baja, Mexico, and corresponding off shore islands to the north. Uncommon in Californian MP.

6. *Callisotoma guerreroensis*
 Tuskes & Tuskes, 2019, new species
 [Figures 6a-c]

Description. Shell sturdy, ground color light yellow-brown (straw). Protoconch off-white to

straw, 1-1.2 whorls. Postnuclear whorls (PNW) 1-4 straw colored; relatively flat, often lustrous copper; suture lightly impressed. **PNW 1-2** three beaded threads. **PNW 3** four beaded/non-beaded threads. Whorls nearly flat. **PNW 4-5** Shoulder five beaded threads, subsutural and shoulder threads prominent; four-five threads on lateral surface beaded/not beaded. **PNW 5**, shoulder lightly rounded and light brown flammules present. **PNW 6** Shoulder angulate with five beaded cords, beads alternating cream/straw; lateral surface nearly vertical, five - six straw cords, mostly non-beaded; some interspaced threads present; flammules present. **PNW 7** Shoulder angulate, at approximately 40 degrees with six beaded cords and lightly bead/nonbeaded thread between cord. Diagonal flammules raised/not raised with alternating brown/cream, markings; below last prominent cord of shoulder the angle abruptly changes to nearly vertical (80-90 degrees). Lateral surface, 8-9 threads, beaded/ mostly non-beaded with fine interspace threads; 2-3 peripheral cords above lower suture, alternating brown marking slightly rectangular/longer rectangular cream markings. **PNW 8** Shoulder angulate, at approximately 35-40 degrees with 8-9 beaded cords on shoulder and fine threads interspaced. Prominent diagonal flammules on shoulder alternate cream and brown, raised / not raised. The lateral surface descends at 86-90 degrees with 8-9 beaded cords, interspaced with smooth fine shallow straw threads; Peripheral band, with 4 cords, alternating brown square marking with larger cream rectangular bar, cords beaded, alternating cream/straw. Base with 24-27 low straw cords with/without very shallow beading, fine interspace threads present, varying number of basal cords with alternating cream and straw markings; cords proximal to columella broader. Columella white, columellar scar white, shallow and lustrous. Aperture slightly oval, outer lip cream, margin lightly crenate; inner shell lightly lustrous.

Diagnosis. *Calliostoma guerreroensis* has been confused with *C. gloriosum* (Figure 5a-c). Mature and subadults of *C. guerreroensis* have a unique profile; as the whorls have a well-defined angulate shoulder sloping at approximately 35°, to the lateral surface, which abruptly changes to 80-90° to the peripheral area; basal threads few to many with alternating cream and light brown spotted cords; post-nuclear whorls 1-4 often with metallic copper luster between the cords. *Calliostoma gloriosum* has somewhat uniformly curved body whorls, basal threads lack alternating colored spotting, and ground color does not overlap that of *C. guerreroensis*.

Paratype variation. The intensity of the peripheral band is variable and often not notable in juveniles. Ground color may be slightly darker among juveniles. Number of basal cords with alternating cream/light brown spots variable but always present. Shell colorations may be more intense and contrasting than the holotype. The slope of the shoulder and periphery are always notable especially after the 5th or 6th whorl, with only moderate variation in large subadults and the mature shell. Juvenile shells typically lack the distinct pattern of mature shells; subadults generally have the shape and markings of adults, but lack bulk. A 23 mm shell with 6.5 whorls, collected north of Guerrero Negro, BCS has a more contrast yellow-straw ground color and not quite as angular, but the threads, cords, shape and markings on the basal threads consistent with *C. guerreroensis*.

Holotype. LACM 3640. 1 mature specimen. Shell height/width 32.0 × 29.4 mm.

Type Locality. Baja California Sur, Mexico, 24°37.2'N, 112° 01.00'W. 5.45 mi. 230° from Punta Entrada, Bahia Magdalena. 24-27 m sand.

H/W 32.4 × 29.4 mm, R/V Velero IV, 3 May 1950.

Paratypes. 1 adult, 1 juvenile. Baja California, Mexico, 28°17.43'N - 14°32.32'W off Laguna Guerrero Negro, 20-30 fms. H/W 23.6 × 22.5 mm, Mary Ricaud 1965 SBMNH 616620; 3 juveniles, 1 subadult. Baja California, Mexico, 27°57'N, 115°08.5'W. Kellett channel S. of Isla Cedros, 37 m, pebbles/shale. H/W 15.3 × 15 mm, 12.5 × 12 mm, 8.3 × 8.0 mm 6.8 × 6.6 mm. R/V Searcher, 20 Oct. 1971. Dead collected. LACM 71-159.9; 2 subadults. Baja California Sur, Mexico, 27°52.0'N, 115°12.7'W, Twelve Fathom Reef off Isla Natividad, 22 m. H/W 14.9 × 13.3 mm, 14.5 × 14.0 mm. R/V Searcher, 21 Oct. 1971, McLean & LaFollette. LACM 71.165.10; 1 subadult. Baja California Sur, Mexico, 27°43.3'N, 115°00.05'W, Punta Rompiente, 15 m, under kelp. H/W 16.4 × 14.1 mm. R/V Searcher, 21 Oct. 1971, McLean & LaFollette. LACM 50.141.4; 11 juvenile specimens. Baja California Sur, Mexico, 27°17.6'N, 114°30.0'W, Bahia San Cristobal, 31m. H/W 2.9 × 3.0 mm to 9.5 × 9.1 mm. R/V Searcher, 24 Oct. 1971, McLean & LaFollette. LACM 71-173.4; 4 juvenile specimens. Baja California Sur, Mexico, 27°12.5'N - 114°28.8'W, Punta San Pablo. 21-30 m. H/W 13.8 × 13.4 mm, 13.3 × 12.6 mm, 11.0 × 10.0 mm, 10.9 × 10.0 mm. R/V Searcher, 25 Oct. 1971, McLean & LaFollette. LACM 71.178.19; 2 subadults. Baja California Sur, Mexico, 24°37.2'N, 112° 01.00'W. 5.45 mi. 230° from Punta Entrada, Bahia Magdalena. 24-27 m sand. H/W, 16.4 × 15.5 mm, 14.7 × 14.5 mm. R/V Velero IV, 3 May 1950. LACM 50-41.4.

Other material examined but not included in type series. 2 juvenile specimens. Baja California Sur, Mexico, 27°37.52'N, 114°50.62'W. 14-18 m. Under kelp off Cabo Thueloe. H/W 11.5 × 10.6 mm, 6.8 x broken base. R/V Searcher, 23 Oct. 1971. McLean &

LaFollette. LACM 71-170.16; 1 juvenile, Baja California, Mexico. 27°57'N, 115°08.5'W. Kellett channel S. of Isla Cedros, 37 m, pebbles/shale. H/W 6.8 × 6.6 mm. R/V Searcher, 20 Oct. 1971. Dead collected. LACM 71-159.9.

Etymology. Named after the closest community to where the first specimen was identified from, Guerrero Negro, Baja California Sur, Mexico ("BCS").

Distribution. Currently known from the area of Isla Cedros, Baja California, south to Bahia Magdalena Bay, BCS, this distance spans approximately 800 km. The occurrence further south is expected but not known.

Remarks. The majority of the *C. guerreroensis* in museums are subadults or juveniles found at depths between 20-37 m and collected during two research trips, 1950 and 1971. Access to the Pacific coast of BCS is limited and the collection of shells by individuals is prohibited. Initial specimens were found mixed with *C. gloriosum* in museum collections.

7. *Calliostoma keenae* McLean, 1970
[Figure 7]. Holotype: LACM 1272.
Off Laguna Beach, California, 106-109 m.

Shell height. 12-15 mm. Shell drab green-brown to yellow-brown with a peripheral band that has alternating olive and white markings. Whorls convex with beading absent on upper whorls but present on lower whorls. Brown flammules may be present. Based on an earlier photo of the holotype, the peripheral band has lost much of the color.

Range. Southern California south to the Jaime Bank off Cabo San Lucas, BCS and Isla Clarion in the Revillagigedo group off western Mexico. The species has also been found within the Gulf

of California, Skoglund & Koch (1993) reported collecting specimens at Los Frailes, Isla Danzante both Baja Sur, and off Bahia de Los Angeles, Baja California. Other records include, 58 Fathom Bank, 12 miles of Laguna Beach, Orange County, California; San Diego, California at 58 m (CSDOMP); Isla Cedros 117-119 m, Baja California; Dewey Channel between Isla Natividad and Punta Eugena 44-46 m, San Jaime Bank 137 m, Baja California Sur; and Emerson (1995) reported the species from Isla Clarion at 35-110 m. The shallowest collection was a small specimen collected by Ron McPeak on a sea mount near Bahia Asuncion, BCS at 26-30 m (Hertz & Hertz, 1984). Rare.

8. *Calliostoma ligatum* Gould, 1849
[Figures 8a-c]. Holotype: USNM 5608.
Puget Sound, Washington.

Shell height. 24-30 mm. Shell color is light to dark brown with light brown to beige cords that lack beads (Figure 8a). Occasionally shells have brown flammules below the suture and are referred to as form *pictum* (Figure 8b) while other shells may have a blue band on the upper whorls, form *caeruleum* (Figure 8c) that tend to fade over time. Conditions that result in the outer shell being eroded away reveal a persistent bright iridescent blue layer of shell that is not visible in intact specimens.

Collections that have not been curated for many decades may still inventory this species as *C. costatum* Martyn, 1784. *C. ligatum* is seldom seen in southern California but is most likely to be found in the North-West Channel Islands which are impacted by the cool California Current, and in deeper water well below the thermocline. We have found the species commonly at Morro Bay (Oregonian MP) during minus tides on rock covered with debris,

sponge, algae, and bryozoans, but have never personally observed this species off San Diego.

Range. Cook Inlet, Kachemak Bay, Kenai Peninsula, Prince William Sound, Alaska south to Santa Barbara California, after which the species is uncommon. A dead specimen was found in San Diego, California (Bishop & Bishop, 1973). The southern most record is from Isla San Benito at a depth of 83-95 m, Baja California. Uncommon in the Californian MP.

9. *Calliostoma nepheloides* Dall, 1913
 [Figures 9a-b]. Syntype: USNM 96637.
 Panama Bay, Panama, 86 m.

Shell height. 15-23 mm. Whorls are flat with small, tightly spaced spiral threads that are beaded above and below the suture. There are two prominent peripheral cords, the upper most is beaded, the lower one is not. Most shells are olive-brown in coloration, some have darker flammules and the upper whorls can have a brown metallic luster.

Range. Punta Abreojos, west of Laguna San Ignacio, BCS, Mexico south to Panama (McLean, 1971). McLean (1971) gives a depth range of 73-120 m, which is consistent with other museum specimens we have examined. Houston (1980) stated the species is found intertidally; but this has not been confirmed by others, if correct this would be the first record from shallow water. Uncommon in the Californian MP.

10. *Calliostoma sanjaimense* McLean, 1970
 [Figure 10]. Holotype: LACM 1269.
 San Jaime Bank, Baja California Sur, Mexico, 137 m.

Shell height. 10-15 mm. The whorls are flat sided, shell dark yellow. Threads and cords are

strongly beaded yellow-brown with a prominent peripheral band of alternating brown and white patches. When described by McLean (1970), it was known from only four specimens, all from the San Jaime Bank, west of Cabo San Lucas, BCS at 137 m. LaGrange (1992) collected a live specimen while dredging at 140-160 m on the Nine Mile Bank off San Diego. A specimen was collected at a depth 68 m in the Gulf of Panama.

Range: San Diego, California south to Panama. Rare.

11. *Calliostoma supragranosum* Carpenter, 1864
 [Figures 11a-d]. Holotype: USNM 14925,
 San Diego, California.

Shell height. 7-11 mm but older museum collections contain specimens from 8-19 mm. Shells are orange-brown, light brown to brown. Beaded threads are expected especially on the upper whorls and adjacent to the sutures. Some individuals lack notable beading. When present, the peripheral band consists of alternating light to darker brown markings that may vary in intensity.

Variation in shell color and pattern includes; brown with light blue trim on prominent threads and the presence of weak flammules. The uncommon blue shell may have a prominent peripheral band (Figure 11b). *Calliostoma supragranosum* is perhaps the most frequently encountered species in southern California. The species is usually under rocks and on overhangs in association with bryozoans, sponge, and colonial ascidian tunicates at depths of 2-50 m. Somewhat common below 20 m, but populations are localized.

Comparison *Calliostoma supragranosum* vs. *Calliostoma splendens*.

Calliostoma splendens (Carpenter, 1864) has been treated as a junior synonym of *C. supragranosum* for more than 50 years yet *C. splendens* still appears in popular literature and on some web-sites. Based on a small sample in our personal collection there appeared to be two distinct phenotypes, that is, until hundreds of museum specimens were examined and found that the number of threads beaded/not beaded is variable as is the presence/absence and intensity of contrasting peripheral markings. The confusion starts when Carpenter (1864) published the description of both *C. supragranosum* and *C. splendens*, and did not illustrate them or provide a diagnosis. The description of *C. splendens* is based on a juvenile of 4.8 mm and two paratypes in the range of 3 mm. As such they have been commonly sorted not by shell characteristics, but rather size and depth of collection. We visited the USNM to examine type specimens for both *C. supragranosum* USNM 14925 and *C. splendens* USNM 16278 and have illustrated them (Figures 11c and 11d).

The descriptions of both were written in Latin and in our opinion somewhat generalized. The holotypes of *C. supragranosum* and *C. splendens* were both described as brown, but over the past 150 plus years they have become light tan. Figures 11c and 11d show both holotypes to scale in relation to each other, otherwise the relative size of the threads and the distance between would be out of proportion. The holotype of *C. splendens* was dead collected and the lip partly missing.

A review of the later works of Olroyd 1927, Keep 1947, P.A. Morris 1966 and Abbott 1974, indicates there is little agreement as to habitat or characteristics that would separate *C.*

supragranosum from *C. splendens*; this includes size, shape, color, beading, peripheral banding and depth. Van Winkle Palmer (1958) published a compilation of many West Coast shells described by Carpenter, which included black and white illustrations.

Range. Monterey Bay to San Diego, California, south along the Baja coast and off shore islands such as Guadalupe (Chace, 1958) to at least Punta San Pablo just north of Bahia Asuncion, BCS, Mexico. Occasionally locally common.

- 12. *Calliostoma tricolor* Gabb, 1865**
 [Figures 12a-b].
 Syntype: ANSP 38184.
 San Pedro, California.

Shell height. 15-22 mm, shell fragile. A distinctive species with prominent beaded threads. The shell color is yellow-brown to light brown. Approximately every 3rd to 5th thread is colored with alternating clusters of dark brown and white beads forming distinctive bands (Figure 12a). The greater the frequency of these darker beaded threads, the darker the shell is in appearance (Figure 12b). In the Californian MP the species is found subtidally on rock or sand habitats. Specimens have been collected in grab samples at 100 m (CSDOMP) off San Diego, California.

Range. Santa Cruz, California south to Bahia Tortuga south of Punta Eugena, BCS. Locally common intertidally north of Point Conception. Uncommon in the Californian MP.

- 13. *Calliostoma turbinum* Dall, 1896**
 [Figures 13a-b].
 Holotype: USNM 122578.
 Santa Barbara Channel, Point Conception, California, 183 m.

Shell height. 15-22 mm. The shell structure is thin and delicate with a coppery iridescence. There are prominent peripheral cords. The first few threads below the suture are beaded, the remainder are typically not beaded or only minutely beaded.

The species has been taken while dredging at 140-160 m on the Nine Mile Bank off San Diego (LaGrange, 1992); at 109 m off Point Conception and Santa Catalina Island at 90-180 m. Although most specimens taken in grab samples off San Diego are at 90-100+ m, a few have been found as shallow as 27-30 m (CSDOMP). There is a small juvenile shell in the SDMNH from Isla Cedros collected at 15 m, but may have been transported into the shallower water by a hermit crab. The deepest specimen off California was from 914 m.

Range. Point Conception, Santa Barbara County, California, south to Isla San Benito at 126-144 m, Baja California Mexico. The species is taken with some frequency in deep water samples off San Diego. Rare.

14. *Calliostoma variegatum* Carpenter, 1864
[Figure 14]. Holotype: USNM 4201.
Puget Sound, Washington.

Shell height. 17-24 mm. The shell is soft yellow and the apex of a freshly collected shell may be yellow or purple; whorls are flat. Threads strongly beaded that are light brown to orange-brown separated by light yellow. A unique specimen with a white shell and purple apex was taken off San Diego, California and is in the collection of Chuck Reitz. With age, shells in collections often lose much of their color and become more subdued.

In the Oregonian MP off Vancouver, British Columbia, Canada this species is taken by SCUBA divers as shallow as 10 m and by

dredge to at least 146 m. In southern California it is a deep-water species collected by dredging at 70 m off Santa Catalina Island (McLean & Gosliner, 1996), Nine Mile Bank 140-160 m off San Diego (LaGrange, 1992), Cortez Bank 230 m, and 126-144 m off Isla San Bonita, Baja Ca., Mexico. Rare in the Californian MP.

Range. Gulf of Alaska East of Afognak Island, (Clark, 2018), south to Isla Cedros, Baja California (McLean & Gosliner, 1994). A rare deep-water species in the Californian MP.

***Akoya* Habe, 1961**
Type species; *Calliostoma akoya*
Ikebe, 1942

The genus *Akoya* consists of moderate to deep water white shells, with beaded/not beaded spiral cords/threads in varying numbers. The presence of the periostracum may give the shell a gray appearance if not removed. Their habitat and appearance is closer to *Otukaia* Ikebe, 1943 than *Calliostoma*. *Calliostoma* from Alaska to the Pacific coast of Baja California Mexico, have shells with multiple colors, other than white. With improved analytical techniques we may better understand the relationship of similar appearing deep water white calliostomids. Do they represent convergence from multiple genera, or will they be found to form a tight clade?

15. *Akoya platinum* (Dall, 1890)
[Figures 15a-f]. Holotype: USNM 96558.
Station 2839 near Santa Barbara Island,
California, 756 m.

***Calliostoma titanium* McLean, 1984.** Holotype:
LACM 1995. R/V Velero, 8.3 km SE of
Santa Catalina Island, California, 256-274 m.

***Calliostoma bernardi* McLean, 1984.** Holotype:
LACM 1996. R/V Velero, off SE end of
Santa Catalina Island, California, 241-271 m.

Akoya platinum average height is 27.9 mm (N=34), most mature specimens range from 24-33 mm, large specimens to 37 mm; form *titanium* averages 28.6 mm (N=17), most mature shells ranged from 22-33 mm, large specimens 36 mm; form *bernardi*, average 28.7 mm (N=18), mature shells measured 24-33 mm, large specimens to 36.6 mm. The average and maximum height were all within 1 mm (Table 1). Shells white, peripheral cord prominent, numerous threads below peripheral cord to base, threads and cords above peripheral variable in number, size, and beading. Subsutural cord present/absent, subsutural area may be tabulate to varying degrees; columellar scar white, lip smooth, inner shell lustrous light green to pink.

Species and forms	Sample size	Average Height mm	Largest shell mm
<i>A. platinum</i>	34	27.9	37
form <i>titanium</i>	17	28.6	36
form <i>bernardi</i>	18	27.7	36.6
Non assigned	26	28.3	36.6

Table 1. Measurements of 95 mature shells in the *Akoya platinum* complex.

Calliostoma platinum is dredged at 100 to 700+ m or taken associated with deep-water bait traps. Although found on the traps they are not always associated with the bait. In Alaska they have been photographed via Remote Operated Vehicle in deep water feeding on gorgonian Stone, *et al.* (2014).

Range. Icy Bay, Gulf of Alaska (Clarke, 2018) south to San Diego and probably similar habitat

in Baja California, Mexico. Depth 180-700 m. Rare.

Discussion of *Akoya platinum* Complex. McLean (1984) in his descriptions of *Akoya titanium* and *A. bernardi*, provided a diagnosis that included *A. platinum* and is summarized as follows: Whorls 3 - 4 of *A. titanium* similar to *A. platinum*, both lacking threads; *A. platinum* shell weak, *A. titanium* shell sturdy with subsutural tabulation and numerous fine cords (threads) on final whorl. "*Calliostoma bernardi* is closest to *C. titanium*" but smaller and has strong spiral cords on all whorls compared to *A. titanium*. Having recently examined the holotype of *A. platinum* at the USNM, the shell is only weak in the sense that nearly all of the lip is missing and there is a hole on the opposite side of the shell.

LaGrange acquired the first large series of shells from east end of Santa Catalina Island at 350 m. These shells were examined by McLean in 1984, who concluded that *C. titanium* and *C. bernardi* are conspecific. La Grange (1998) discussed these findings, illustrated specimens and designated *C. bernardi* a junior synonym of *C. titanium*. The holotypes of *A. titanium* and *A. bernardi* were both collected south east of Santa Catalina Island and the holotype of *A. platinum* was collected off Santa Barbara Island which is adjacent to Santa Catalina Island. We treat *A. titanium* as a synonym of *A. platinum*. Forms *titanium* and *bernardi* represent steps along a character cline.

As indicated in Table 1, the average height and maximum height are all within less than 1 mm. In our analysis, each of 95 mature shells were evaluated against six characters and were then compared to the type of all three taxa (Table 2). Of the 95 mature shells, 33.7 % were identified as *A. platinum*, 18% as form *titanium*, and 19% as form *bernardi*. The remaining 29.3% could

not be assigned to any of the three taxa based on a minimum of 75% similarity and were distributed as follows: intermediate characters between *A. platinum* and form *titanium* 9.5%, between form *titanium* and form *bernardi* 6.3%, between *A. platinum* and form *bernardi* 2%, and 11.5% were evenly distributed between all three (Illustration 1). Table 2 provides collective information regarding character distribution.

	<i>platinum</i> N = 32	<i>titanium</i> N = 17	<i>bernardi</i> N = 16	Intergrade N = 28
Perpheral cord #1				
S	29	2	10	
W	3	15	8	
N	0	0	0	
Threaded above peripheral cord on body whorl #2				
S	19	0	17	14
W	13	15	1	12
N	0	2	0	2
Threads beaded above peripheral cord #3				
S	0	0	15	8
W	0	12	3	8
N	32	3	0	12
Carinations on postnuclear whorl 1 #4				
S	24	5	17	15
W	0	0	0	0
N	8	12	1	13
Shoulder below suture of body whorl tabulated #5				
S	0	3	12	14
W	25	7	6	13
N	7	7	0	1
Shoulder cord beaded weak #6				
S	0	1	15	5
W	7	9	3	13
N	25	7	0	10

Table 2. Number of shells exhibiting specific characters.

In summary, all of the type specimens came from either Santa Barbara Island or Santa Catalina Island which are adjacent to each other. There does not appear to be a difference in average size or maximum height of the shells (Table 1). McLean recognized *bernardi* as a synonym of *titanium* (LaGrange, 1998). Our

sample of 95 mature shells documents to some extent the variability. Figures 15a-h illustrate some of the intermediate forms in this complex. The difference between *A. platinum* and form *titanium* is less than the difference between *titanium* and form *bernardi*. *Akoya platinum* is the least ornate and form *bernardi* the most, and are at opposite ends of a character continuum with *C. titanium* and the other 27.2% of the non-assigned shells between them.

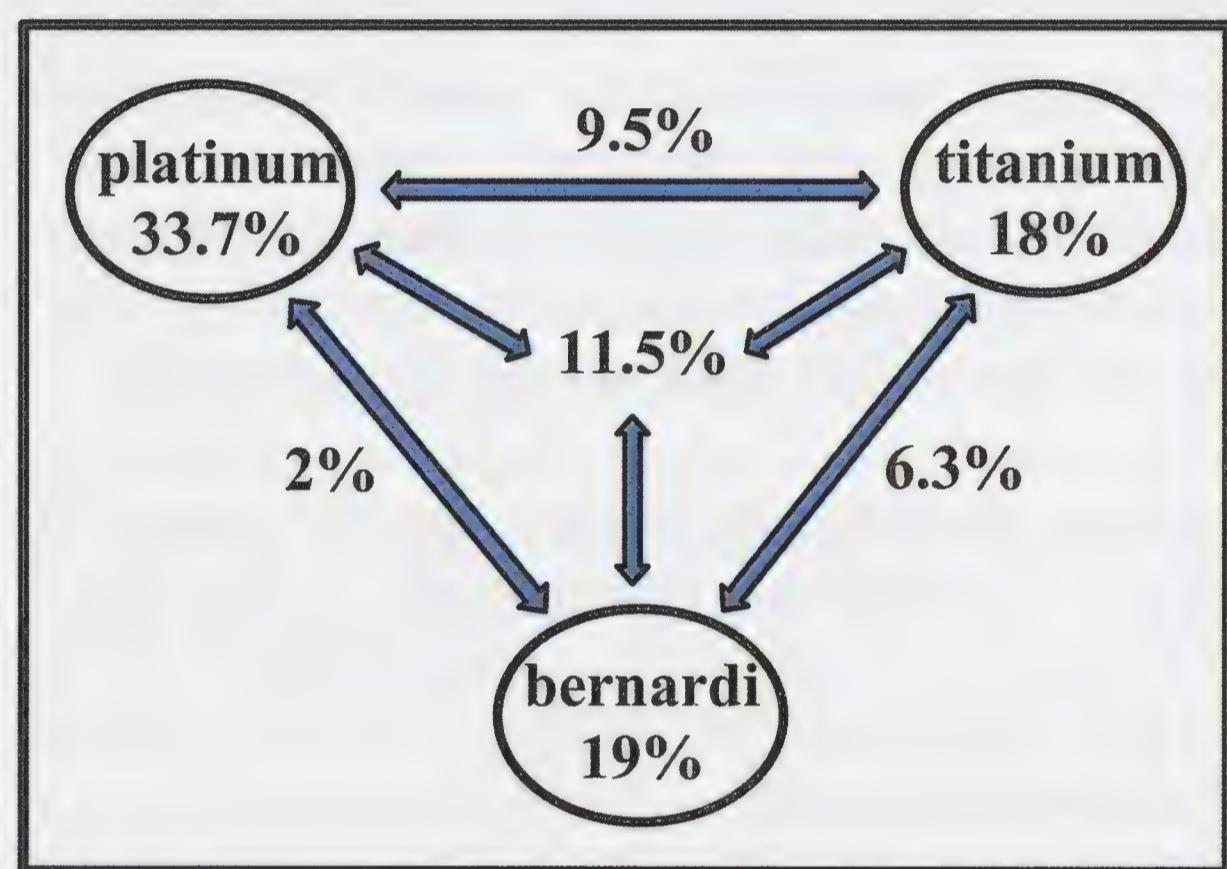


Illustration 1. *Akoya platinum* complex. Affinity of 95 shells. Based on the type specimens, 29% of the shells could not be assigned to a specific phenotype.

ACKNOWLEDGEMENTS

We thank Larry Catarius, Roger Clark, John LaGrange, Don Pisor, and Chuck Reitz for providing data from their collection regarding shells in the *Akoya platinum* complex. We thank each of the following for providing access to their collections and museum assistance: the City of San Diego Ocean Monitoring Program; Natural History Museum of Los Angeles County, Lindsey Groves & Dr. Jan Vendetti, Santa Barbara Museum of Natural History, Dr. Daniel Geiger & Paul Valentich-Scott; San Diego Museum of Natural History; Carnegie Museum Pittsburg, Dr. Timothy Pearce; the United States National Museum Smithsonian, Dr. Christopher Meyer & Yolanda Villacampa

for holotype photos; Academy of Natural Sciences Philadelphia, Dr. Paul Callomon; and, the Scripps Institution of Oceanography.

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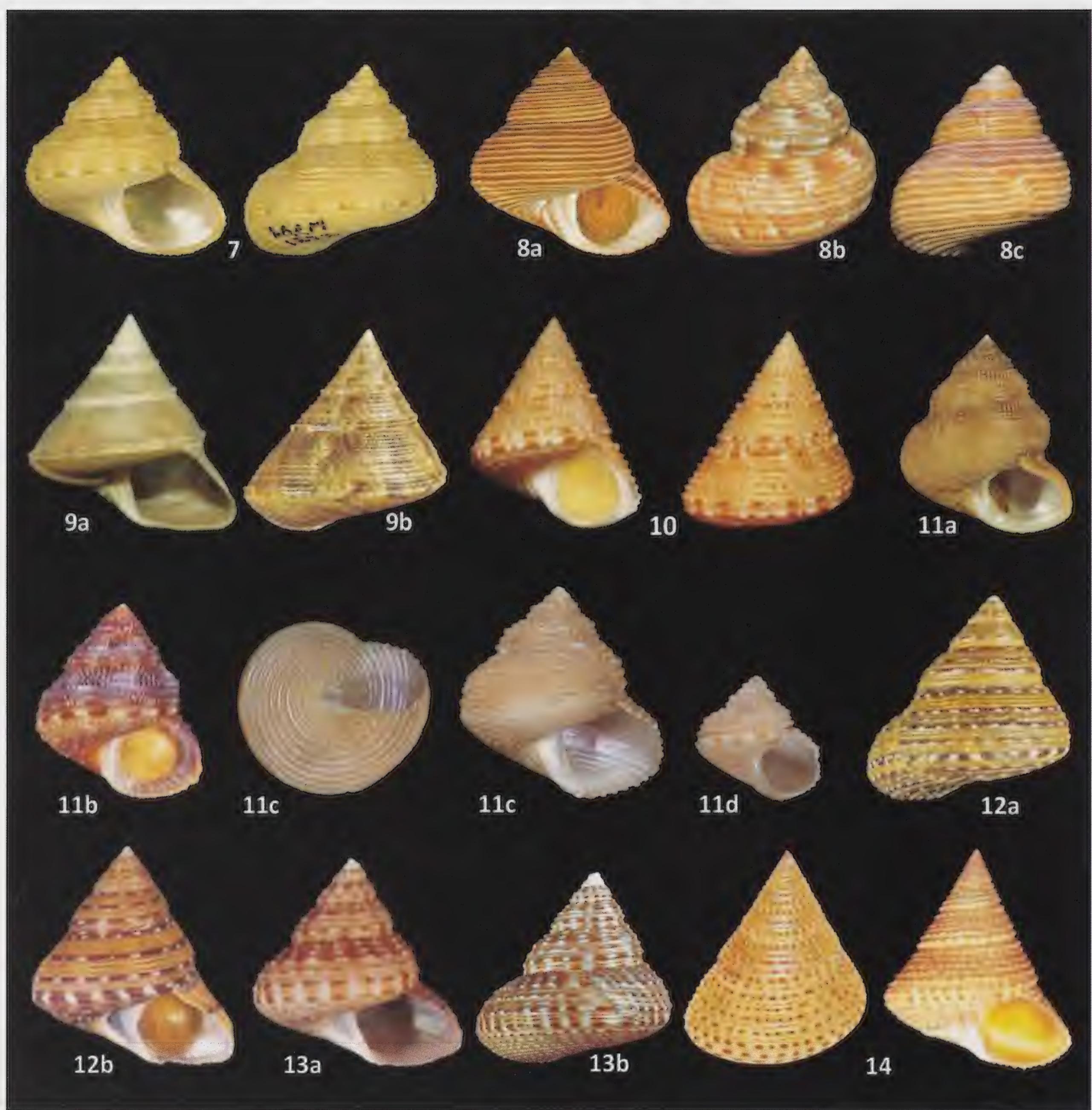
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Marginella hayesi

Brian Hayes



Figures 1 - 6. Figure 1: *C. annulatum* 34 mm, Point Loma San Diego CA. Figure 2: *C. canaliculatum* 37 mm. Point Loma, San Diego, CA. Figure 3: *C. eximium* (Figure 3a) 25 mm (Figure 3b) 32 mm. Scammons Lagoon, Baja Sur, Mexico (BCS). Figure 4: *C. gemmulum* 12.5 mm False Point, San Diego, CA. Figure 5: *C. gloriosum* (Figure 5a) 27 mm Mission Bay, San Diego, CA. (Figure 5b) 25 mm. (Figure 5c) 27.4 mm, both Morro Bay, CA. Figure 6a: *C. guerreroensis* Holotype, 32 mm, Punta Estrada, BCS. Mexico (LACM 3640). Figures 6b-6c: *C. guerereroensis* (paratypes). Figure 6b: 13.9 mm. Figure 6c: 14.9 mm subadults, both Punta Pomplente, BCS, Mexico. (LACM 71-161-16).



Figures 7 - 14. Figure 7: *C. keenae* Holotype 14.9 mm, 58 Fathom Bank, off Laguna, Orange County, CA. (LACM 1272). Figure 8: *C. ligatum* (Figure 8a) 29 mm, Morro Bay, CA. (Figure 8b) flammealed form *pictum*. (Figure 8c) purple ringed form *caeruleum*. Figure 9: *C. nepheloides* Panama Bay, Panama, (Figure 9a) 17 mm, (Figure 9b) 17.6 mm. Figure 10: *C. sanjaimense* 16 mm, 9 Mile Bank off San Diego, CA. (LaGrange). Figure 11: *C. supragranosum* Mission Bay, CA. (Figure 11a) 9.5 mm, (Figure 11b) 8.1 mm. (Figure 11c) *C. supragranosum* Holotype 14925 USNM 8.3mm. (Figure 11d) *C. splendens* Holotype 16278 USNM 4.7 mm. Figures 11c & 11d to scale. Figure 12: *C. tricolor* both Morro Bay, CA. (Figure 12a) 20.5 mm, (Figure 12b) 20.6 mm. Figure 13: *C. turbinum* both from off-shore San Diego, CA. (Figure 13a) 19.5mm, (Figure 13b) 13.4 mm. Figure 14: *C. variegatum* 19 mm, off-shore San Diego, CA.



Figure 15. *Akoya platinum* complex: *A. platinum* = Figures 15a & 15b. Examples of transitional shells (Figures 15 c & 15d) to form *titanium*. Form *titanium* (Figure 15e). Examples of transitional shells to form *bernardi* (Figures 15f & 15g). Extreme form of *bernardi* (Figure 15h). All eight shells measured between 31 and 33 mm in height and were collected at depths from 216 m to 350 meters off San Diego and Los Angeles, southern California. Beige shells are still covered with their periostracum.

The screenshot shows the homepage of the Thelsica website. At the top, there's a navigation bar with links for 'ACCUEIL', 'BOUTIQUE', and 'QUI EST THELSICA ?'. The main banner features a large image of a green and yellow shell. Below the banner, there's a news section with the heading 'Articles from New Caledonia' by Thierry Vulliet. The news items mention 'Phasmoconus (Fulgiconus) santinii' and 'Umbilia hesitata portlandensis'. To the right, there's a 'SHELL TRIP' section titled 'rusty annulus' with a small image and some descriptive text. At the bottom, there are links for 'Voir toutes les actus' and 'Voir tous les albums'. The footer includes a 'NEWS SHELLS' section and a 'NOUVEAUX COQUILLAGES' section.

**The illustration of *Retizafra intricata* Hedley, 1912
(Gastropoda: Columbellidae) from the coastal central Queensland:
Citizen Scientists and their role in systematic practice**

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ABSTRACT Many Australian small molluscan taxa are often overlooked, falling by the wayside and therefore, and remaining relatively unknown to the wider collecting community. This paper redescribes and illustrates *Retizafra intricata* Hedley, 1912, a species that has not been illustrated within the literature for over a century. Many species are listed in databases, but they are often void of illustrative examples making positive identification problematic. Furthermore, this paper refines the syntypes and declares a lectotype to give greater taxonomic clarity. Within the discussion of this paper, the role of the citizen scientist is elucidated. Issues of how attitudinal change within some institutions can lead to the alienation of individuals, particularly those with life-long knowledge in their chosen field.

KEY WORDS Columbellidae, Australia, *Retizafra*, Mollusca, citizen science

INTRODUCTION

The genus *Retizafra* Hedley, 1914 consists of a few dozen relatively small shells that are infrequently encountered by collectors. Many modern publications show illustrations of new species that facilitate recognition (Willson, 1994; Monsecour and Monsecour, 2016, 2018). However, many older texts have not been illustrated or annotated since the original description was written (Brazier, 1877; Hedley, 1901). These original descriptions often failed to provide adequately illustrated material that aid field workers to identify many species that maybe encountered (Brazier, 1877). There has been a renewed interest in the micro-mollusca, particularly as a consequence of the work of the Muséum National d'Histoire Naturelle in the

New Caledonian region (Monsecour and Monsecour, 2016).

This renewed interest and subsequent publications containing *Retizafra* has led to an increase in citizen scientists actively looking for these new taxa. The lack of literary material on historically described taxa that is readily available to the amateur is problematic. The failure to provide adequate identification of small historically described taxa in the modern literature has created a reference gap for the citizen scientist. Therefore, the need to illustrate and describe the species contained within this paper, *Retizafra intricata* Hedley, 1912, is a consequence of practical engagement with citizen scientists and their quest for taxonomic certainty in identification.

SYSTEMATICS

Superfamily Buccinoidea Rafinesque, 1815
 Family Columbellidae Iredale, 1916

***Retizafra* Hedley, 1914**

Type Species. *Pyrene gemmulifera* Hedley, 1907 (= *Retizafra gemmulifera* Hedley, 1907).

Original Description. “For some small ‘Columbella’ do not quite conform to *Zafra*, I suggest a division *Retizafra*. In size and form they correspond [to *Zafra*], but differ by the clathrate sculpture. Also *Retizafra* inhabit deeper water” (Hedley, 1914: 326).

***Retizafra intricata* Hedley, 1912**

(Figures 1 and 2)

Type locality. Katow, Papua New Guinea (now known as Mawatta, Papua New Guinea).

Type material. There are 8 syntypes in the original Australian Museum lot C. 8069 (Brazier, 1877). Hedley (1901, pl. 16, fig. 6) illustrated an 8 mm high example out of the syntype set, and we herein declare that specimen to be the lectotype (Figure 1).

Synonymy.

Columbella (Anachis) clathrata Brazier, 1877, p. 229.

= *Columbella clathrata* Brazier -
 Hedley, 1901, p. 123, pl. 16, fig. 6.

Pyrene intricata Hedley, 1912, p. 151.

= *Retizafra intricata* Hedley - Hedley,
 1914, p. 326.

Original Description. “Shell ovately fusiform, yellowish white, polished, longitudinally roundly ribbed, ribs smooth, interstices clathrate, suture canaliculated, noduled above and below, whorls 6, convex, the last lower half

transversely grooved on the back giving the surface a noduled appearance; aperture white, nearly oblong ovate, columella straight, with thin lip, having three white nodules, peristome thin at edge, thickened internally, having eight tubercles, the second upper one prominent, somewhat lirate, sinuate at the upper part, canal short, narrow” (Brazier, 1877: 229-230).

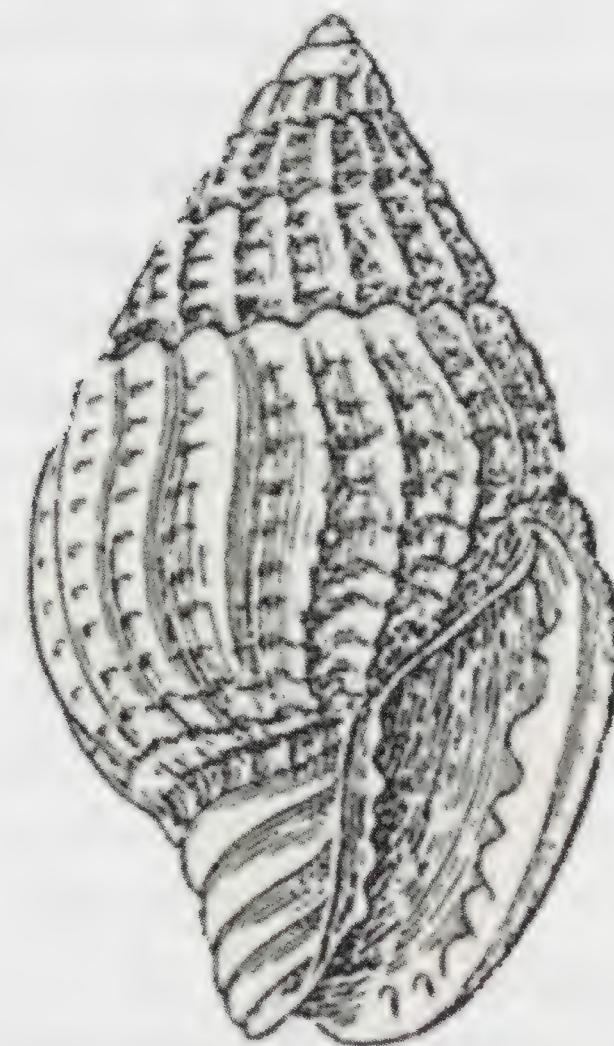


Figure 1: The lectotype of *Columbella clathrata* Brazier, 1877 (synonym = *Retizafra intricata* Hedley, 1812) (Hedley, 1901, p. 123, pl. 16, fig. 6).

Secondary Text. “It has been shown in Paleontology the name of *Columbella clathrata* has been thrice proposed. As Brazier’s choice of this name is thereby invalidated a substitute is here suggested” (Hedley, 1912: 151).

Supplementary Diagnosis. The shell is small, fusiform, and solid. The shell has a uniformly cream colouration. The triangulate and orthostrophic protoconch is smooth and glossy, consisting of 4 whorls, with a well defined indented suture. The teleoconch has 16 to 18 axial costae. These are transected by three or four spiral cords that form distinctive nodules as they cross the costae, giving the teleoconch a

pustulated appearance. The first sub-sutural cord has more pronounced nodules that are slightly paler in colouration, and continue onto the body whorl. The body whorl is coarsely sculptured with axial costae that are crossed with raised spiral cords forming distinctive nodulations which diminish dorsally towards the outer lip. The base of the shell is distinctly convex, with the point of inflection on the lower quarter of the shell. This point of inflection also marks a change in form and colour, as the shell develops broad spiral pale cords that are smooth and separated by narrow incised interspaces. The aperture is ovate. The inner labrum is concave with seven centrally raised nodules. The inner lip is smooth and of the same colour of the shell. The parietal wall is sigmoid, with five cords that are located between the points of inflection. The shell has a terminal growth form that is represented by a thick calloused labrum.

Habitat. The original habitat records that came with the description indicate that the types were collected on a sandy mud substrate in 14 m (Brazier, 1877). The new examples were found intertidally on calcareous algae growing in fine sandy mud. The new location is famous for its extreme tidal range which leaves a large expanse of sandy mud tidal flats that are exposed at low tide. These flats are treacherous, with areas of quick sand. The neighbouring mangrove-lined creeks are inhabited by estuarine crocodiles, and the tidal flow is so great that the incoming tide may form a tidal bore. This is most pronounced in the nearby Styx River where the bore may reach 0.5 m (Department of Environment and Science, 2018).

Distribution. At present, this species is known to range from Karratha in Western Australian around the top of Australia, to Brisbane. The new collection site is Clairview, Queensland

(22°07'34'' S, 149°32'35'' E): Collectors Trevor and Marguerite Young (2009).

Variability. There is very little variability found in the newly located population. All specimens examined show uniformity in colour of the shell as well as similarities in structural presentation. Brazier (1877) noted that the sculpture is variable in intensity.

DISCUSSION

There has been a long historical reliance on the role of amateur collectors to provide information to institutions on distributions of known species and the discovery of new taxa (Klemann-Junior, 2017). This relationship is under serious threat of being lost. Historically, the discovery of new taxa rested in the realm of academia, but with the dwindling numbers of professional taxonomists, there has been an increasing role for the citizen scientist as the source for many new taxa (Maxwell, *et al.*, 2016, 2017). This is particularly the case in Australia where there is a discord between the Government propaganda on the need for increased action on taxonomic conservation in contrast to practical taxonomy, specifically in terms of funding actual zoological discovery (Commonwealth of Australia, 2010). The authors would suggest this lack of practical advance of government policy is a reflection on the move away from taxonomic practice within universities to a more ecological and climate change focused science research programs. It is therefore critical to the future of systematics that the role of classical taxonomy in species descriptions not be discounted.

While the Australian Government lacks interest in scientific discovery in favour of monitoring, the call for more practical roles for citizen scientists increases. However, there is a growing disjunct between these amateur naturalists and

the institutionally molecular focused taxonomists. Often institutional professionals discount these dedicated amateurs' knowledge, or the material they present, on the basis of a lack of viable molecular material. This rejection extends to amateurs' distributional understanding of the biology and ecology of the organisms they study. One classical example was the discovery of a nudibranch from Queensland that was hereto only known from an isolated population in the Philippines. When reported to an institutional "expert", the record was rejected outright as false data (Tassey Weinreich, personal communication).

The molecular fad within institutions has seen the decline in classical taxonomy (Tahseen, 2014). The professional molecular taxonomist is almost alienating the serious citizen scientist from the taxonomic process as the focus is moved from the shell to its molecular DNA contents. This can have a negative effect on those lifelong citizen scientists whose studies rely on classical taxonomic practice; but they need not fear. Classical taxonomic practice is the most reliable process of defining the extent of nature (Válka and Filho, 2007). Species are reference points that allow us to build the web of life in terms of connectivity and thereby resolve evolutionary theories of radiation based on field observations. When examining "cryptic species" that dwell in phylogenetic species conceptionalities, one must ask where is the test for reticulatory potential that was carried out when they were erected? Drawing the line of diversification in terms of genetic diversity is one of the ongoing debates with the use of molecular data where classical taxonomy still plays a crucial role (Pante *et al.*, 2015). Classical taxonomy provides the basis of species delimitation with morphology and spatiotemporal positioning data and grounds species hypothesis in the real world. Genetically cryptic species are wonderful in theoretical

conceptuality, however they are impractical taxonomically (*e.g.* Penny and Willan, 2014).

Unlike institutional collections that are often reflective of limited sampling of an area, the citizen shell collector may often visit an area repeatedly over an extended time period building an invaluable resource in terms of a longitudinal sampling and knowledge of changes in the species composition through time. Furthermore, as these avid collectors go about their private classification of material for their collections, they are often the first to uncover both novel taxa, and those taxa that have been lost within the literature, and this highlights the importance of citizen scientists in progressing taxonomy. Furthermore, it is imperative the citizen scientists who have decades of experience not be cast aside by molecular taxonomists along with those taxonomic practitioners who hold to a classical approach to the species identification.

ACKNOWLEDGEMENTS

The authors would like to thank Trevor and Marguerite Young for providing the specimens from their systematic collection that enabled this publication. Thanks are offered to Mr. Henk Dekker for his assistance in identification and comments. The authors would also like to thank Anne Butler of Brisbane for reading and editing the manuscript.

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Figure 2. *Retizafra intricata* Hedley, 1812 from Clairview in central Queensland. A = 6.5 mm, in the Trevor & Marguerite Young Collection. B = 7.0 mm, in the David P. Berschauer Collection.

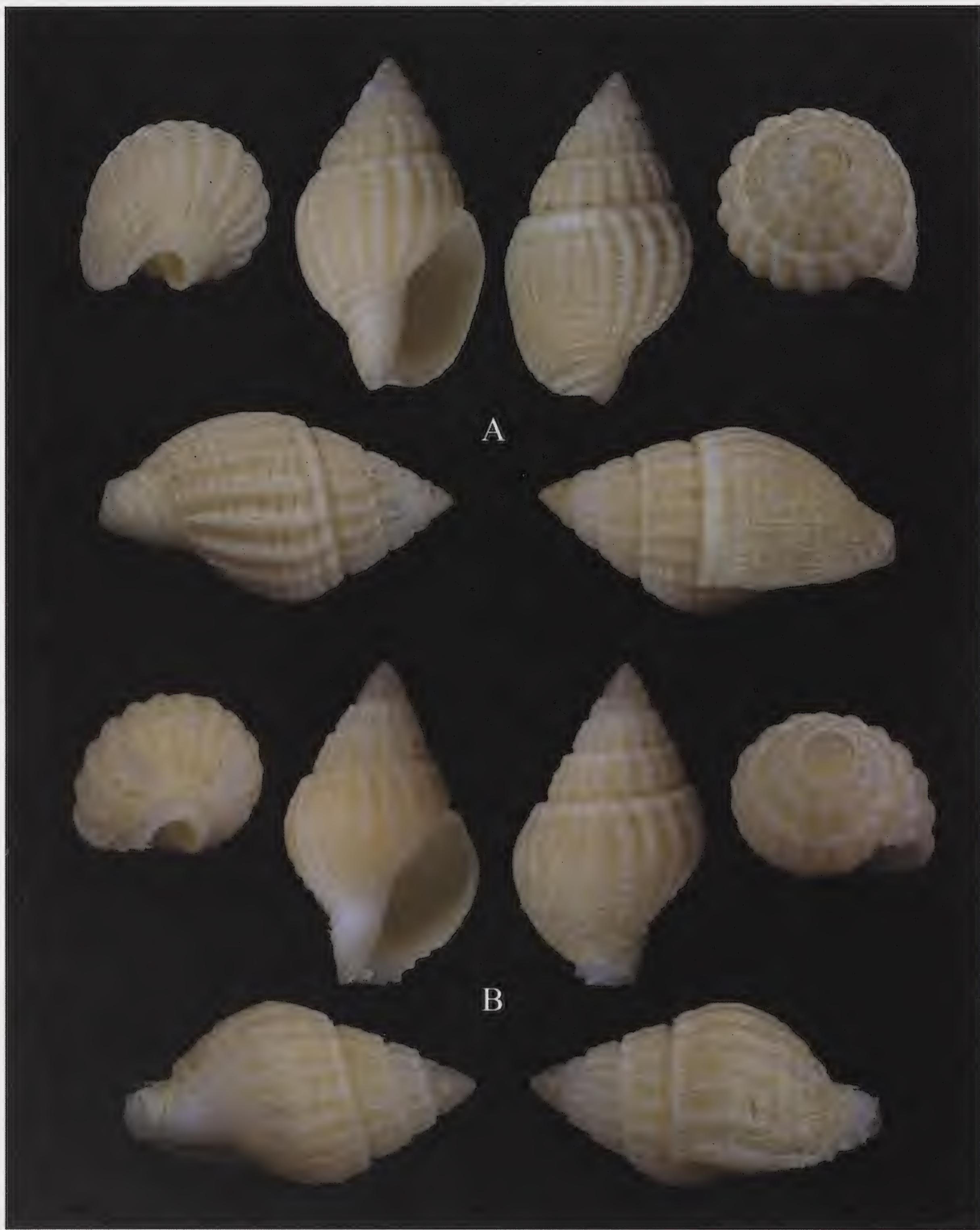


Figure 3. *Retizafra intricata* Hedley, 1812 from Clairview in central Queensland. A = 7.5 mm, in the Aart Dekkers Collection. B = 5.0 mm, in the Henk Dekkers Collection.

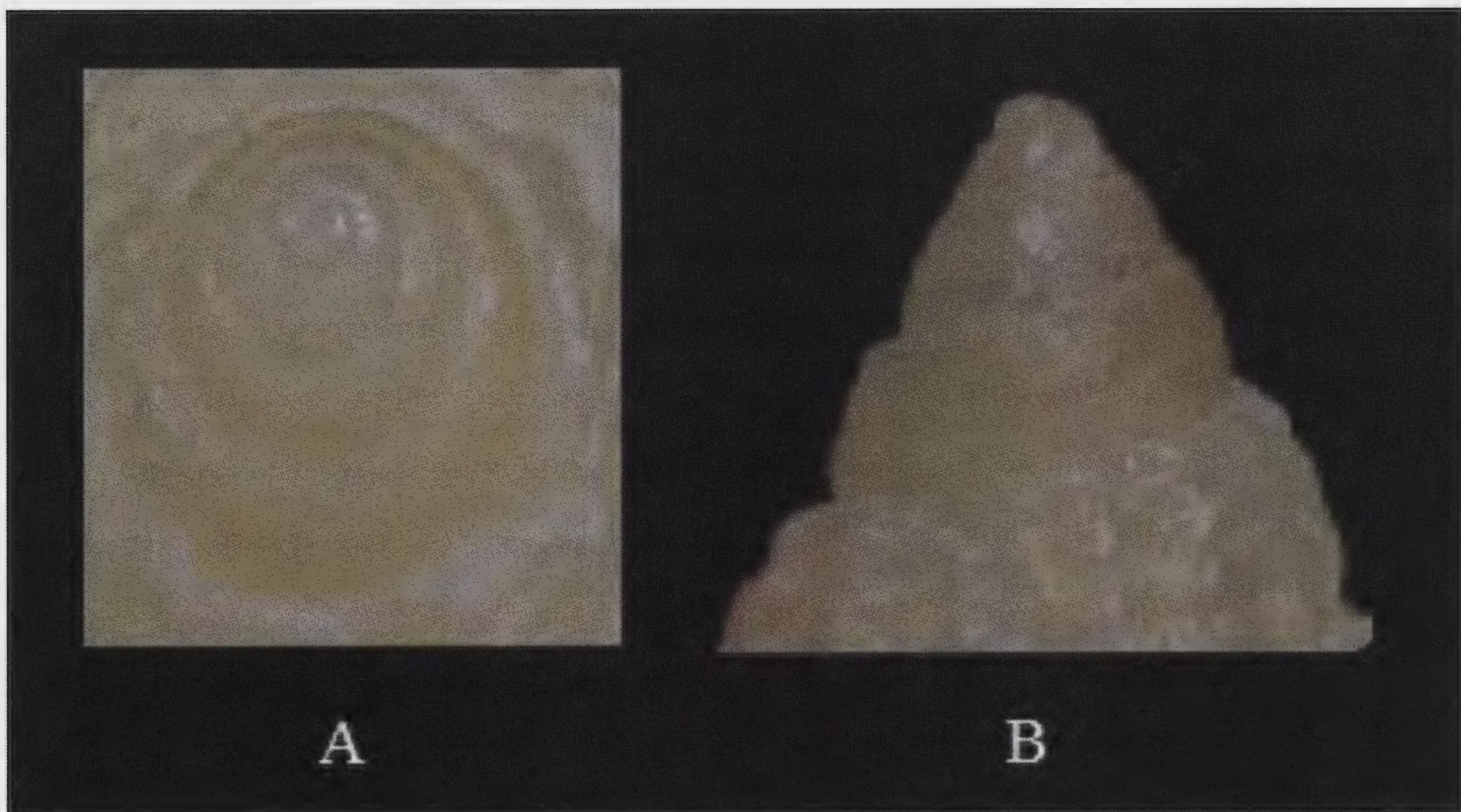


Figure 4. *Retizafra intricata* Hedley, 1812 - protoconch views. A = top view, B = side view.



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Two New species of *Amphidromus* (Gastropoda: Camaenidae) from Cambodia & Laos

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ABSTRACT Two new species of genus *Amphidromus* Albers, 1850 are described from Cambodia and Laos and compared to four other species of this genus: *Amphidromus koenigi* Thach & Huber, 2018, *Amphidromus cognatus* Fulton, 1907, *Amphidromus stungtrengensis* Thach & Huber, 2018 and *Amphidromus thachi* Huber, 2015.

KEYWORDS Gastropoda, Helicoidea, Camaenidae, *Amphidromus*, Kratié, Cambodia, Attapeu, Laos, new taxon.

INTRODUCTION

Amphidromus is a genus of the family Camaenidae with many species collected in Cambodia and Laos. In the summer of 2018, specimens of what appeared to be two new species of this genus were collected. These specimens were not listed in the works by Parkinson, Hemmen & Groh (1987), Abbott (1989), Dharma (2005), Stanisic, Shea, Potter & Griffiths (2010), Schileyko (2011), Tan *et al.* (2011), Parsons (2014), Raheem *et al.*, 2014, Inkhavilay, Sutcharit & Panha (2017), Lok & Tan (2018), or Thach (2005, 2007, 2012, 2016, 2017, 2018). In this article, the taxa found on this expedition in the summer of 2018 are described as new to science.

Abbreviations.

FMNH	Field Museum of Natural History, Chicago, USA
NMHN	National Museum of Natural History, Paris, France
NHMUK	Natural History Museum, London, UK
NNT	Collection Dr. Thach

SH	Shell height
SW	Shell width
BH	Body whorl height
AH	Aperture height

SYSTEMATICS

Class Gastropoda Cuvier, 1797
Superfamily Helicoidea Rafinesque, 1815
Family Camaenidae Pilsbry, 1895
Subfamily Camaeninae Pilsbry & Olsson, 1954
Genus *Amphidromus* Albers, 1850
Type species of genus: *Helix perversus*
Linnaeus, 1758

Amphidromus laii Thach, 2019
new species
(Figures 1-8)

Description. Shell small for the genus (measuring in average height between 19.9 mm and 23.9 mm), elongate tapering in shape with width 52.3% of height (see Table 1). Spire moderately tall, sutures deep. Body whorl inflated and measuring about 66.5 % shell height, periphery rounded. Outer surface

ornamented with many multicolored spiral bands and intermittent axial stripes at spire whorls. Sculpture consists of weak axial striae and conspicuous subsutural ribs (marked by “s” in Figures 2, 5). Aperture wide with external pattern visible within, occupying 46.8% of the shell height, outer lip translucent, slightly reflected, regularly convex with posterior end strongly turned rightward. Umbilicus slightly open, columella also translucent, curved and bordered by dark purple band followed by a black band. Background color yellow with black apex and spiral bands, carmine red subsutural bands, brown axial stripes and turmeric yellow bands at mid-whorls.

No.	1	2	3	4	5	6
SH (mm)	19.9	22.9	22.1	22.0	21.7	23.9
SW (mm)	10.7	11.7	11.5	11.2	11.6	12.7
SW/SH	0.54	0.51	0.52	0.51	0.53	0.53
Mean SW/SH	0.52					
BH (mm)	13.6	14.7	14.8	14.2	14.6	16.2
BH/SH	0.68	0.64	0.67	0.65	0.67	0.68
Mean BH/SH	0.67					
AH (mm)	9.4	10.6	10.3	9.8	10.5	11.4
AH/SH	0.47	0.46	0.47	0.45	0.48	0.48
Mean AH/SH	0.47					

Table 1. Morphometrics of *Amphidromus laii* Thach, 2019.

Diagnosis. The new species is characterized by small adult size, translucent outer lip and columella, elevated subsutural ribs and turmeric yellow spiral bands at mid-whorls.

Type material. HOLOTYPE 19.9 mm high (Figures 1, 4, 5a, 8) in FMNH with Registration No: FMNH 386361.

Other Material Examined. Paratypes: all from type locality, Paratype 1, 22.9 mm (Figures 3, 5b) and Paratype 2: 22.1 mm (Figure 2) in NNT, Paratype 3: 22.0 mm (Figure 6), Paratype 4: 21.7 mm (Figure 7) and Paratype 5: 23.9 mm (not illustrated).

Type Locality. Kratié, Northeastern Cambodia.

Habitat. Among leaf litter.

Etymology. This new species is named after Huỳnh Lai of Vietnam for providing the type material.

Discussion. The new species is close to *Amphidromus koenigi* Thach & Huber, 2018 (Figure 9, 10) as it presents with black spiral bands at base, carmine red bands below the sutures and aperture with external pattern visible within, but differs mainly in its smaller adult size, not having a red outer lip and columella, and in the presence of conspicuous subsutural ribs and axial stripes at the spire whorls. *Amphidromus cognatus* Fulton, 1907 (Figures 11 & 12) resembles the new species in having a yellow background color and black spiral bands at base, but differs mainly in not having a translucent outer lip and columella, not having carmine red bands below sutures, and a more inflated body whorl with constricted sutures and absence of axial stripes at the spire.

Amphidromus donchani Thach, 2019
new species
(Figures 13-20)

Description. Shell medium-sized for the genus (measuring in average height between 25.5 mm and 35.5 mm), elongate tapering in shape with width 54.2% of height (see Table 2). Spire tall, sutures deep. Body whorl inflated and measuring about 69% shell height, periphery rounded. Outer surface ornamented with broad axial stripes that are usually faint or lacking at body whorl and strongly curved at spire whorls. Dark-colored varix seldom present. Sculpture consists of weak axial striae and whitish subsutural bands. Aperture elongate and occupying 49.2% of the shell height without external pattern visible within, outer lip highly calloused. Umbilicus closed, columella slightly curved and also highly calloused. Color brown with white apex, black outer lip and columella.

No.	1	2	3	4	5	6
SH (mm)	35.5	25.5	29.0	29.5	34.9	35.0
SW (mm)	19.0	14.8	15.8	15.4	19.2	18.2
SW/SW	0.54	0.58	0.54	0.52	0.55	0.52
Mean SW/SW	0.54					
BH (mm)	24.0	17.4	20.5	20.4	24.5	23.7
BH/SW	0.68	0.68	0.71	0.69	0.70	0.68
Mean BH/SW	0.69					
AH (mm)	17.4	12.7	14.4	14.5	17.5	16.5
AH/SW	0.49	0.50	0.50	0.49	0.50	0.47
Mean AH/SW	0.49					

Table 2. Morphometrics of *Amphidromus donchani* Thach, 2019.

Diagnosis. The new species is readily recognized by black outer lip and columella, brown aperture, purple red parietal wall and presence of broad axial stripes, especially at spire.

Type material. HOLOTYPE 35.5mm in MNHN (Figures 13, 14, 18, & 20b) with Registration No: NMHN IM-2000-34202.

Other Material Examined. Paratypes: all from type locality, Paratype 1, 25.5 mm (Figure 15), Paratype 2: 29.0 mm (Figures 16, 17, & 19) and Paratype 3: 29.5 mm (Figure 20a) in NNT; Paratype 4: 34.9 mm and Paratype 5: 35.0 mm (not illustrated).

Type locality. Attapeu, South Laos.

Habitat: Around trees.

Etymology. This new species is named after Donald Chan of Hong Kong for his interest in studying land snails.

Discussion. The new species is close to *Amphidromus stungtrengensis* Thach & Huber, 2018 (Figures 21 & 22) as it presents with a black outer lip and columella, but differs mainly in having a brown aperture, not having a black apex, not having carmine red subsutural bands and not having a dark brown outer surface. *Amphidromus thachi* Huber, 1907 (Figures 23 & 24) resembles the new species in having a black outer lip and columella, but its outer surface is white (not brown), the anterior end of its outer lip is more pointed, and its columella is longer and more curved, its parietal wall is not purple red, its aperture is more deviated to the lateral sides and axial stripes are lacking.

ACKNOWLEDGEMENTS

I express thanks to the Natural History Museum of London, UK for use of the photograph of *Amphidromus cognatus*, and to the anonymous reviewers for useful comments.

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Figures 1-8: *Amphidromus laii* Thach, 2019, Kratié, Cambodia - **1:** Holotype 19.9 mm with ventral view in FMNH - **2:** Paratype 2, 29.0 mm with reflected outer lip in NNT - **3:** Paratype 1, 25.5 mm with spire view in NNT - **4:** Holotype with dorsal view - **5a:** Holotype with enlarged subsutural bands - **5b:** Paratype 1 with enlarged subsutural bands in NNT - **6:** Paratype 3, 34.9 mm with ventral view - **7:** Paratype 4, 29.5 mm with dorsal view - **8:** Enlarged apex and umbilicus of holotype - **9, 10:** *Amphidromus koenigi* Thach & Huber, 2018 for comparison, photo of Thach, 2018 - **11, 12:** *Amphidromus cognatus* Fulton, 1907 for comparison, photo of NHMUK.



Figures. 13-20: *Amphidromus donchani* Thach, 2019, Attapeu, Laos - 13: Holotype 35.5 mm with ventral view in NMHN - 14: Holotype with with dorsal view - 15: Paratype 1, 25.5 mm with ventral view in NNT - 16: Paratype 2, 29 mm with dorsal view in NNT - 17: Paratype 2 with ventral view in NNT - 18: Holotype with reflected outer lip - 19: Paratype 2 with spire view - 20a: Paratype 3 with enlarged apex in NNT - 20b: Holotype with enlarged umbilicus - 21, 22: *Amphidromus stungtrengensis* Thach & Huber, 2018, 30.1 mm for comparison, photo of Thach, 2018 - 23, 24: *Amphidromus thachi* Huber, 2015, 33.3 mm for comparison, photo from Huber, 2015.

The Fossil Cypraeidae of the Buckingham Member (Unit 10), Tamiami Formation of Southern Florida: (Mollusca: Gastropoda: Cypraeidae)

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ABSTRACT The oldest recorded fossil Cypraeidae from southern Florida date from the late Zanclean-early Piacenzian Pliocene (circa 3.8-3.6 million years ago - hereinafter "mya") in the Myakka Lagoon System, a shallow water estuary that lies beneath the present day Sarasota area. Shallow water sea grass beds and nascent shoreline mangrove forests hosted seven Cypraeidae species in five genera. Determining the origins of these species is challenging as only steinkern casts have been found in adjacent lower layers. However, enough features are present in two of the casts to infer the ancestral presence of two of the genera. For the other genera and species, a comparison of features with the northern Florida Panhandle Cypraeidae populations dating from the Burgdigalian Miocene (16-20 mya) does suggest certain affinities. However, no direct lineage can be asserted with any confidence. The sea bed deposit layer of this period has been designated the Buckingham Member of the Tamiami Formation of southern Florida.

KEYWORDS Duplinian Subprovince, Buckinghamian Subprovince, Tamiami Formation, Buckingham Member, Cypraeidae, fossil, *Akleistostoma*, *Siphocypraea*, *Pahayokea*, *Calusacypraea*, *Pseudadusta*, Myakka Lagoon System, Sarasota area, Polk Peninsula, Kissimmee Embayment, Kissimmee River Valley, St. Lucie Peninsula.

INTRODUCTION

"The Cypraeidae of Plio-Pleistocene southern Florida produced the single largest radiation of cowrie shells, known from one locality, ever found on Earth. ... [T]he cowrie fauna of the Everglades and adjacent areas represented ... 104 species, making it one of the largest groups of macrogastropods found in late Neogene southern Florida." (quote from the Introduction to Jewels of the Everglades, The Fossil Cowries of Southern Florida, 2018, by Edward J. Petuch *et al.*). This book is a comprehensive presentation of these cowrie species presented by genus and subgenus, rather than by their place in geologic time. By time sequence, the species radiation began with the Buckingham Member (Unit 10) of the Tamiami Formation (circa 3.8-3.6 mya). This paper examines the

commencement of the cowrie species radiation during this period of time. This also marks the beginning of successive disappearances and emergences of new cowrie species confined to their individual formations and members through to the latest Pleistocene (12,000 years ago (hereinafter "kyr").)

Peninsular Florida.

Before the Miocene (24 mya), peninsular Florida did not exist. Thirty-two mya, a small, shallow carbonate bank had developed on the underlying bedrock Florida Platform (a rampart between the Gulf of Mexico and the Atlantic Ocean). It lies over 150 km off the coast of Georgia, in what is now the northern part of peninsular Florida, and was separated from the mainland by a wide shallow seaway (Suwannee

Strait). The bank was the highest point of six thick (2-6 km), carbonate formations that had developed on the platform prior to the Miocene. As the Miocene approached, erosion of carbonate areas to the north flowed to the south and allowed the bank to become an island (Orange Island). Ultimately, this, combined with the growth of coral reef systems around the island, led to the closure of the Suwannee Strait and the merger with the mainland in the early Miocene. By 18 mya, peninsular Florida remained emergent despite a period of high sea levels. At the time, the future Everglades would have been a small area on the southeast of the Florida Platform. The platform and these formations still underlie peninsular Florida today.

Initially, peninsular Florida only covered the northern area of the peninsula with its peripheral areas being filled in over time. By mid-Pliocene (3.8-3.6 mya), the northern area had filled out to a great extent. However, the Polk Peninsula in the center of present day peninsular Florida and the St. Lucie Peninsula on the eastern coast constituted its southern edge. In the present day Sarasota area on the

western side of the Polk Peninsula, there existed a shallow, estuarine lagoon fed by the Myakka River. In the present day Kissimmee River Valley, between the two peninsulas, there was a long, shallow embayment.

Geological Framework.

Just what and where are the Buckingham Member and the Tamiami Formation of south Florida? To understand these geological concepts, it is necessary to start from a higher view and work down from there. Geologists have divided the world into geologic provinces which are defined as “any large area or region considered as a whole, all parts of which are characterized by similar features or by a history differing significantly from that of adjacent areas” (Glossary of Geology, 1980). The U.S. Geological Survey, last updated in the mid 2000s, designated the region from Cape Cod to the Mexican border and then to the Yucatan Peninsula as the Atlantic Plain Province. In the present day, it is the flattest of the American provinces, sloping gently seaward in a series of terraces far into the Atlantic and Gulf of Mexico where it forms the continental shelf.



Figure 1. Map reflecting the Tamiami Subsea. ML = Myakka Lagoon System; K = Kissimmee Embayment; O = Okeechobee Patch Reefs; CS = Caloosahatchee Strait; LS = Loxahatchee Strait. Adapted from Petuch *et al.* 2018, figure 1.5 at p. 37.

The Atlantic Plain Province of today covers an immense area. However, during previous epochs, land formations and coast lines did not conform to the present day. For the latest Pliocene-earliest Pleistocene, Petuch (2004) proposed the Paleo Caloosahatchian Province, which extended from Nova Scotia, around Florida and into the Gulf of Mexico as far as Texas. In addition, four subprovinces were proposed, but only two are relevant to this paper: the Duplinian Subprovince of North Carolina and the Buckinghamian Subprovince of southern Florida. The former extended south to the northern edges of the Buckinghamian and can be considered a shared overlap zone, having shared many genera and species with its southern neighbor. The latter extended as far north as Tampa in the west and Cape Canaveral in the east.

Within subprovinces, geologists have recognized formations which may also have members. Formations consist of distinct strata in a geological region that have comparable visible features which distinguish the strata from all other adjacent formations. Together, two or more sequential formations can form a group, the formations of which also share certain features. In south Florida, the Okeechobee Group consists of eight formations, dating from the mid-Pliocene (cir. 3.8-3.6 mya) to the latest Pleistocene (12 kya). The oldest, the Tamiami Formation (Tamiami) of Southern Florida spanned the late Pliocene and contained five members.

The Tamiami Formation (named after the Tamiami Trail between Naples and Miami) underlies the entire Everglades region. There are no natural surface outcroppings within the formation, rather the strata (beds) consist of clays in limited quantities confined to shorelines and estuaries, quartz and limestone sand in beds

as well as intermixed with bioclasts, mostly mollusks and corals.

Within a formation, members represent part of a formation but distinct strata within the formation. Within the Tamiami Formation, the members (strata) represent separate and different depositional sea beds that were deposited as the result of sea level and climate changes over time. The Buckingham Member (named after the town of Buckingham on the Caloosahatchee River) also underlies the entire Everglades region with the exception of the area around Tampa. However, only the areas around the shallow, estuarine Myakka Lagoon System, present day Sarasota area, and the Kissimmee Embayment, present day Kissimmee River Valley, are relevant to this paper. The former contained the only Cypraeidae recorded in the Buckingham while the two combined served as the areas of the next Cypraeidae radiation.

The Pliocene of Southern Florida (Buckingham Time).

Scientists use the geological time scale to describe the timing of events that have shaped the history of the earth. Based on the study of the earth's strata, they have divided the earth's history into successive time periods. For our purposes, the Pliocene Epoch (5.3 to 2.6 mya), which followed the Miocene Epoch (23.0 mya to 5.3 mya), is the most relevant to this paper. In Florida, during a crossover period between the late early Pliocene (Zanclean) and the early late Pliocene (Piacenzian) 3.8-3.6 mya, Buckingham time, the sea environments were subject to the colder water conditions which were also experienced in the Duplinian Subprovince. The growth and development of tropical marine fauna was stunted during this period. This was followed by a warming trend that began circa 3.6 mya and intensified to such an extent that it produced tropical conditions, including

extensive coral reef systems south of the Myakka Lagoon System and Kissimmee Embayment. However, we are getting ahead of ourselves.

Tamiami Formation and Members.

The Tamiami Formation was deposited in the latter part of the Pliocene from circa 3.8 to 2.58 mya and represents the thickest and richest shell fossil beds in southern Florida. As there are no natural outcroppings in the formation, particularly in the Sarasota area and Kissimmee Valley, the only access to collecting sites is through quarries, canal digs and construction sites.

In 1982, in the APAC pit at Sarasota, Florida, a deep quarry cut exposed a wall with clearly defined strata. These strata provided the basis for Petuch to assign unit numbers to the strata within the formations. The strata represent successive sea beds, one on top of the other. Subsequent studies of the quarries in the Kissimmee Embayment led to the assignment of equivalent unit numbers in that location. The unit numbers run from 11 to 0, with the higher the number the older the strata. The Buckingham Member (Unit 10) was the oldest unit to contain recorded Cypraeidae species.

NOTE: In a formation, Equivalent Members may also be designated to differentiate other distinct areas which exhibit marine fauna similar to the member. Members and their Member equivalents together represent geologic time markers, allowing geologists to date strata.

The Buckingham's best and largest exposures were in the Sarasota APAC and Quality Aggregates Pits and consisted of quartz/lime sand and mud with closely packed mollusk bioclasts intermixed. The four meters thick

exposures indicate a relatively long lived depositional period. The Buckingham extended into the Kissimmee Embayment where similar exposures were found in its upper reaches. However, in its lower reaches, sediments have been leached leaving only riverine stones/rocks intermixed with broken mollusk fragments. No Buckingham fossil Cypraeidae have been recorded from the Kissimmee Embayment.

Myakka Lagoon System / Kissimmee Embayment.

Named after and fed by the Myakka River, the Myakka Lagoon System was a tropical estuarine habitat, enclosed behind a string of near offshore fringing reefs. It stretched along the southwest coast of the incipient Polk Peninsula in the present day Sarasota area. It consisted of sand and sea grass flats and intertidal mud flats, sections of which fronted mangrove tree forests. The latter were to become common by the beginning of the early Pleistocene (2.6 mya). The intertidal flats were covered by extensive sea grass beds. In its totality, it is known today as the Myakka Lagoon System.

The Kissimmee Embayment was enclosed between the Polk and St. Lucie Peninsulas and behind the Okeechobee Reefs that formed a concave assemblage at the southern mouth of the embayment. It was far larger and more extensive than the Myakka Lagoon System, but its habitat was similar, *i.e.* sea grass beds, intertidal mud flats and mangrove tree forests. Sediments from the Kissimmee River and surrounding land areas eventually entirely filled the embayment, leaving low flatlands north of present day Lake Okeechobee in the Kissimmee River Valley.



0 Unit 0 – Surface sands. 1 meter thick. Fossil Cypraeidae absent.

Fordville Member, Caloosahatchee Formation.

1 Unit 1 - Sand, peat & shell fragments. 2 meters thick. 2 Sarasota species.

Fruitville Member, Tamiami Formation

2 Unit 2 – Quartz sand, shell fragments & large *Hyotissa meridionalis* oysters. 1 meter thick. 20 species: 10 Sarasota & 10 equivalent.

3 Unit 3 – Quartz sand & pearly oyster beds. 2 meters thick. 16 species: 9 Sarasota & 7 equivalent.

4 Unit 4 – “Black Layer”. Rich estuarine fauna, organic rich mud and marsh clams. 3 meters thick. 22 species: 10 Sarasota & 12 equivalent.

Pinecrest Member, Tamiami Formation

5 Unit 5 – Giant worm gastropods. 1 meter thick. NO FOSSIL CYPRAEIDAE recorded.

6 Unit 6 – Large *Hyotissa meridionalis* oysters. 1 meter thick. NO FOSSIL CYPRAEIDAE recorded.

7 Unit 7 – Main bed. Quartz sand, shell fragments, abundant closely packed mollusks & corals. 5 meters thick. 15 species: 8 Sarasota & 7 equivalent (6 Kissimmee Valley restricted).

8 Unit 8 - Giant worm gastropods. 1 meter thick. NO FOSSIL CYPRAEIDAE recorded.

9 Unit 9 - Large *Hyotissa meridionalis* oysters. 1 meter thick. NO FOSSIL CYPRAEIDAE recorded.

Buckingham Member, Tamiami Formation

10 Unit 10 - Main bed. Quartz sand & mud with abundant closely packed mollusks. 4 meters thick. 7 Sarasota species.

Sarasota Member, Murdock Station Formation

11 Unit 11 –Phosphatic clays, abundant gastropods, giant barnacles & scallops. 2 meters thick. NO FOSSIL CYPRAEIDAE recorded.

Figure 2. APAC Pit Stratigraphic Column. Adapted from Petuch & Roberts, 2007, figure 4.3 at p. 73.

Buckingham Member Species.

The seven Buckingham Member (Unit 10) species in five genera shown in Figure 3 are:

- Akleistostoma carolinensis* (Conrad, 1841)
- Akleistostoma (Mansfieldicypraea) crocodila* (Petuch, 1994)
- Akleistostoma (Ingramicypraea) pilsbryi* (Ingram, 1939)
- Siphocypraea (Seminolecypraea) micanopy* Petuch and Drolshagen, 2011
- Pahayokea (Gardnericypraea) erici* (Petuch, 1998)
- Calusacypraea duerri* (Petuch, 1996)
- Pseudadusta buckinghamensis* Petuch and Drolshagen, 2011

For detailed genera and species descriptions, background information and discussion, see Jewels of the Everglades, The Fossil Cowries of Southern Florida, 2018, by Edward J. Petuch, David P. Berschauer and Robert F. Myers.

All seven of the known Buckingham Member Cypraeidae lived in the Myakka Lagoon System. No Cypraeidae species have been recorded from the Buckingham of the Kissimmee Embayment. However, their presence may be inferred given their subsequent emergence in the Kissimmee Embayment during the succeeding Pinecrest Member of the Tamiami Formation, in the early Late Pliocene.

Habitat.

Sea grass beds constituted the most common and widespread habitat for Cypraeidae not associated with coralline habitats in both the Pliocene and Pleistocene. This is true of the Buckingham as well, although the beds were probably not as extensive as in subsequent Members. The strata suggest a quartz sand substrate in a quiet, shallow water environment.

In addition to the sea grass beds, infaunal (fauna that live in the substrate of a soft sea bottom) bivalves as well as oysters were interspersed among large clumps of barnacles, forming separate beds.

Recent Turtle Grass beds support rich faunas of bivalves and gastropods, most of which are restricted to these beds. This suggests that Buckingham Cypraeidae were also dependent upon such beds for their continued survival. The *Calusacypraea* (Petuch, 2004) genera were apparently associated with the mangrove associated mud flats of the Lagoon System.

Origins.

In the Duplinian Subprovince, *A. carolinensis* (Figure 3 A & B) has been found in Virginia, the Carolinas and Florida's western Panhandle, while *A. (I.) pilsbryi* (Figure 3 D) has been found along the Cape Fear River in North Carolina along with *A. carolinensis*. Both were contemporaneous with the Buckingham Member. These two species, coupled other Duplinian species, demonstrate that the molluscan fauna of that subprovince extended south into the Myakka Lagoon System and the Kissimmee Embayment, but no further south.

Again to the north but further back in time, Cypraeidae species have been collected from the Burgdigalian Miocene (late early Miocene, 16-20 mya) of the Chipola Formation in northern Florida Panhandle. However, it is not possible to designate any of these as predecessor species. While the features of the Chipola Cypraeidae suggest certain affinities with the Buckingham Member species, no direct line can be asserted with any confidence.

Farther south, the Middle Miocene Peace River Formations of DeSoto and Charlotte Counties contain only molds and casts as its sediments

are heavily leached by infiltrating ground water. However, two casts (steinkern) were collected at a mine in southwest Polk County, northeast of Sarasota. One cast was described as *Akleistostoma ductor* (Petuch and Drolshagen, 2011) and the second *Calusacypraea polkensis* (Petuch and Drolshagen, 2011). While the former cast was poorly preserved, there were enough inferred features to place it in the *Akleistostoma* Gardner, 1948 genus. It is closest to *A. carolinensis*. The *C. polkensis* cast was also poorly preserved, but there were enough inferred features to place it in the *Calusacypraea* genus, despite a narrower aperture and a less projecting posterior edge on the outer lip. It is probable that there were other ancestors, but that is an unknown at this point.

ACKNOWLEDGEMENTS

This article is based on the related collective works of Dr. Edward J. Petuch which encapsulate his 45 years of field and academic work with the geology, paleogeography and the fossil molluscan fauna of Florida.

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Figure 3. Fossil cowries of the Buckingham Member (Unit 10). A & B = *Akleistostoma carolinensis* (Conrad, 1841); C = *Akleistostoma (Mansfieldicypraea) crocodila* (Petuch, 1994); D = *Akleistostoma (Ingramicypraea) pilsbryi* (Ingram, 1939); E = *Calusacypraea duerri* (Petuch, 1996); F = *Pahayokea (Gardnericypraea) erici* (Petuch, 1998); G = *Pseudadusta buckinghamensis* Petuch and Drolshagen, 2011; H = *Siphocypraea (Seminolecypraea) micanopy* Petuch and Drolshagen, 2011.

A New Cone Shell (Conidae) from the South China Sea

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ABSTRACT A new species of the biconic, deep water conid genus *Turridiconus* Shikama and Habe, 1968 has been discovered in the bathyal zones south of the Pratas Islands, South China Sea. This new taxon, *Turridiconus takahashii* new species, superficially resembles *T. excelsus* (Sowerby III, 1908), both in size and shape and is one of the largest species in the genus *Turridiconus*.

KEY WORDS Cone Shells, Conidae, *Turridiconus*, *T. takahashii*, Pratas Islands, South China Sea

INTRODUCTION

The genus *Turridiconus* is a distinctive group of biconic-shaped deep water cone shells with a wide range across deep neritic and bathyal areas of the Indian and Western Pacific Oceans. Although only 12 species are presently known (listed in the Discussion), many more undescribed *Turridiconus* species are undoubtedly present in deeper water areas along Western Australia, the Indian Ocean, and the South China Sea off the coasts of China and Vietnam. Recently, a well-known shell dealer and diver from Hawaii, Christopher Takahashi, brought to our attention a very large *Turridiconus* species that had been trawled off the Pratas Islands in the South China Sea. A review of the *Turridiconus* literature (Biggs *et al.*, 2010, and Monnier *et al.*, 2018) showed that it represented an undescribed taxon and this newest member of the genus is described in the following sections. The holotype of the new species is deposited in the type collection of the Department of Malacology, Los Angeles County Museum of Natural History, Los Angeles, California and bears an LACM catalog number.

SYSTEMATICS

Class Gastropods
 Subclass Sorbeoconcha
 Order Prosobranchia
 Infraorder Neogastropoda
 Superfamily Conoidea
 Family Conidae
 Subfamily Coninae
 Genus *Turridiconus* Shikama and Habe, 1968

Turridiconus takahashii Petuch and
 Berschauer, new species
 (Figure 1A-D)

Description. Shell large for genus, averaging 56 mm, elongated, distinctly biconic, with spire almost same size as body whorl; shoulder sharply-angled, bordered by large rounded carina; spire whorls very sloping, slightly indented, with carinae of previous whorls projecting above suture, producing distinctly scalariform structure; body whorl smooth and shiny, sculpted with 23-25 shallowly impressed spiral grooves; spiral grooves become finer and more numerous toward anterior end; body whorl dark tan or golden brown, with 2 wide white bands, one anterior of mid-body line and one

around anterior end; white bands marked with rows of small, dark rectangular brown checkers, often aligned as broken longitudinal flammules; wide brown bands marked with scattered large, white, longitudinal flammules, often arranged in zig-zag pattern; spire whorls dark brown, marked with scattered, irregular, large white flammules; edge of shoulder carina and spire whorl carinae marked with small white irregular patches, producing checkered pattern; aperture of uniform width throughout, proportionally very narrow; interior of aperture white; protoconch composed of 2 rounded whorls, proportionally small, pale tan in color.

Type Material. HOLOTYPE - LACM No. 3652. Length 56.4 mm, width 20.9 mm, 250 m depth off the Pratas Islands, Taiwan (Figure 1A & B); **OTHER MATERIAL EXAMINED** - length 56.1 mm, from the same locality and depth as the holotype, in the research collection of the senior author (Figure 1C); length 57.3 mm, from the same locality and depth as the holotype, in the research collection of the junior author (not illustrated); and length 46.5 mm, allegedly trawled at 180 m depth in the East China Sea, in the research collection of the junior author (Figure 1D).

Type Locality. The holotype of *Turridoncus takahashii* was trawled by Taiwanese fishermen from 250 m depth south of the Pratas Islands, Taiwan, northern South China Sea.

Distribution. Known only from 250 m depth in the northern South China Sea, near the Pratas Islands, Taiwan. The species appears to also be present in the central basin of the South China Sea.

Ecology. The new cone was collected along with abundant pleurotomariid gastropods, especially *Mikadotrochus hirasei* and *Bayerotrochus teramachii* (Takahashi, personal

communication). These were trawled on an open sponge-covered sea floor along with *Turridoncus takahashii*.

Etymology. The new cone shell is named for Christopher Takahashi of Kapolei, Oahu Island, Hawaii, who purchased the type lot from Taiwanese fishermen and who first recognized that the shells could represent a new species.

Discussion. Of the known *Turridoncus* species from Japan, the Philippines, and the South China Sea, *T. takahashii* is most similar to the recently-described *T. rizali* (Biggs, Watkins, Corneli, and Olivera, 2010) from deep water off the Philippines (Figure 1E & F). This new South China Sea cone differs from its Philippine congener in being a larger and proportionally more elongated shell with a higher spire and in having a much more elongated body whorl that is less turnip-shaped. With its elongated biconic form and large shell size, *T. takahashii* is also very similar to *T. excelsus* (Sowerby III, 1908) from Japan, the Philippines, and Melanesia (Figure 1G & H), but differs in having coarser and stronger body whorl grooves, in lacking the network of fine dark brown longitudinal flammules around the shoulder and mid-body, and in having less-developed scalariformation on the spire whorls.

The new South China Sea cone is also very similar to the Pliocene fossil *T. gratacapi* (Pilsbry, 1904) from the Kikai Formation of Kikaijima Island, Kagoshima Prefecture, Japan (illustrated in the taxonomic lists produced by R.M. Filmer, under the "Cone Collector" online magazine; 2012). Although closely resembling *T. takahashii*, this extinct Pliocene species is a smaller shell with much more sloping spire whorls, has a smaller and thinner shoulder carina, and lacks the distinct stepped (scalariform) structure seen on the new South China Sea species. Based on its shell

morphology, *T. gratacapi* appears to be the direct ancestor of *T. takahashii* and may represent the late Neogene stem stock for the entire late Pleistocene-Holocene *Turridoncus* radiation of Japan and the Western Pacific region.

The genus *Turridoncus* is now known to contain 12 species which are distributed throughout the Indo-Pacific Region from East Africa to Melanesia and Japan (Biggs *et al.*, 2010, and Monnier *et al.*, 2018). The largest number of *Turridoncus* species occurs in the Philippines and Japan, which probably represents the center of evolution for the genus. These include:

Turridoncus acutangulus (Lamarck, 1810) (Indo-West Pacific; the shallowest-dwelling species)

Turridoncus aequiquadratus (Monnier, Tenorio, Bouchet, and Puillandre, 2018) (Madagascar)

Turridoncus andremenezi (Olivera and Biggs, 2010) (Philippines)

Turridoncus beatrix (Tenorio, Poppe, and Tagaro, 2007) (Philippines)

Turridoncus bicolor (Sowerby I, 1833) (Philippines and Japan)

Turridoncus excelsus (Sowerby III, 1908) (Western Pacific)

Turridoncus miniexcelsus (Olivera and Biggs, 2010) (Western Pacific)

Turridoncus praecellens (Adams and Adams, 1854) (Western Pacific)

Turridoncus rizali (Biggs, Watkins, Corneli, and Olivera, 2010) (Philippines)

Turridoncus subaequalis (Sowerby III, 1870) (Philippines)

Turridoncus takahashii Petuch and Berschauer, new species (South China Sea)

Turridoncus wilmeri (Sowerby III, 1882) (Andaman Sea and Bay of Bengal)

The evolutionary relationships and venom production of *T. acutangulus*, *T. andremenezi*, *T. excelsus*, *T. praecellens*, and *T. miniexcelsus* were recently published by Qing *et al.*, 2017.

ACKNOWLEDGMENTS

We thank Christopher Takahashi of Kapolei, Oahu Island, Hawaii for the generous donation of specimens of the new species for our research.

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Figure 1. Species of *Turrididae* from the South China Sea and Philippines. **A, B** = *Turrididae takahashii* Petuch and Berschauer, new species; holotype, length 56.4 mm, trawled by Taiwanese fishermen from 250 m depth south of the Pratas Islands, Taiwan, South China Sea. **C** = *Turrididae takahashii* Petuch and Berschauer, new species, length 56.1 mm, trawled from 250 m depth off the Pratas Islands (Petuch collection); **D** = *Turrididae takahashii* Petuch and Berschauer, new species, length 46.5 mm, allegedly trawled from 180 m depth in the East China Sea (Berschauer collection); **E, F** = *Turrididae rizali* (Biggs, Watkins, Corneli, and Olivera, 2010), length 24 mm, 150 m depth off Olango Island, Philippines (Berschauer collection). **G, H** = *Turrididae excelsus* (Sowerby III, 1908), length 70.7 mm, 200 m depth off Bohol Island, Philippines (Berschauer collection).

A New Subspecies of *Viduoliva* (Olividae) from Northern Queensland, Australia

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ABSTRACT A new intertidal olive shell of the genus *Viduoliva* Petuch and Sargent, 1986 is described from northern Queensland, Australia. Although referred to as “*Oliva elegans*” and “*Oliva vidua*” in recent works, this large and commonly-encountered olivid is now known to represent an eastern subspecies of the wide-ranging northwestern and northern Australian (Dampierian Province) *Viduoliva westralis* (Petuch and Sargent, 1986). The new subspecific taxon, *Viduoliva westralis elodieae* new subspecies, differs in having a smaller and much more inflated shell and in having a lower, less-exerted spire.

KEY WORDS Olividae, Olivinae, *Viduoliva*, Queensland, Australia

INTRODUCTION

Over the past decade, intensive biodiversity collecting along the Queensland coast, especially between Cairns and Cooktown, has uncovered several new, previously-undescribed endemic mollusks. Some of these new discoveries include the cardiid bivalve *Vasticardium swanae* Maxwell, Congdon and Rymer, 2016, the cowrie *Bistolida stolida lorrainae* Lorenz, 2017, the harpid *Harpa queenslandica* Berschauer and Petuch, 2016 (on offshore reefs), and a previously-unrecognized subspecies of the northwestern and northern Australian *Viduoliva westralis* Petuch and Sargent, 1986. For an excellent description of the muddy sand environments of northern Queensland see Maxwell *et al.*, 2016. This new Queensland subspecies, which had mistakenly been referred to as “*Oliva vidua*” or “*Oliva elegans*” in recent works, is described in the following sections. The holotype of this new taxon, here named *Viduoliva westralis elodieae*, is deposited in the molluscan collection of the Biodiversity Section, Queensland Museum,

Brisbane, Queensland, Australia and bears a QM catalog number.

SYSTEMATICS

Class Gastropoda
 Subclass Orthogastropoda
 Superorder Caenogastropoda
 Order Sorbeoconcha
 Infraorder Neogastropoda
 Superfamily Olivoidea
 Family Olividae
 Subfamily Olivinae
 Genus *Viduoliva* Petuch and Sargent, 1986

Viduoliva westralis elodieae
 Petuch and Berschauer, new subspecies
 (Figure 1 A-F)

Description. The new taxon is described as a geographical subspecies of *Viduoliva westralis* (Figure 1G & H); shell elongated, bulbous, subcylindrical, with distinctly convex sides; shoulder broadly rounded, gradually sloping into body whorl; filament channel very narrow, deeply impressed; spire whorls low, flattened, overlaid with very thick, heavy callus;

protoconch composed of 2 ½ whorls, projecting above spire callus; aperture proportionally wide, straight, flaring slightly toward anterior end; columella with 18-20 low teeth, which become obsolete and over-glazed on older specimens; shell color deep yellow or yellow-green, overlaid with variable amounts of dark green elongated flammules, often arranged in zig-zag pattern; 2 broken bands of widely-separated black or dark brown elongated flammules surround body whorl, with one just below shoulder and one around mid-body; many specimens occur in golden color forms (like holotype), which are mostly bright yellow-orange with faint scattered darker orange flammules; transitional color forms are frequently encountered, where shells alternate between normal green color and golden color morph (Figure 1C & D); columellar callus and interior of aperture white; anterior tip of fascicular callus bright orange; spire callus pale yellow.

Type Material. HOLOTYPE - Length 39.1 mm, intertidal mud flats, off Port Douglas, Queensland, Australia, QM MO85815, (Figure 1A & B); **OTHER MATERIAL EXAMINED** - 3 specimens, lengths 39 mm, 40 mm, and 43 mm, from the same locality as the holotype, in the research collection of the senior author; 3 specimens, lengths 42.4 mm, 37.7 mm, and 41.5 mm, from the same locality as the holotype, in the research collection of the junior author.

Type Locality. On mud flats at low tide, off Port Douglas, Queensland, Australia.

Distribution. The new subspecies ranges from Cairns, Queensland, northward along the Cape York Peninsula to Somerset and Bamaga, at the northernmost tip. The new subspecies extends along the Gulf of Carpentaria side of the Cape York Peninsula southward to at least Nanum, where several specimens were collected on mud

flats at low tide. No specimens of any form of *Viduoliva westralis* have been collected in the Wellsley Islands of the southern Gulf of Carpentaria, demonstrating that the nominate subspecies from the Northern Territory and *elodieae* from Queensland are geographically isolated from each other.

Ecology. *Viduoliva westralis elodieae* lives in muddy sand, on intertidal sand flats, in nearshore areas all along the Queensland coast north of Cairns. The animal is especially active at night and can be collected on mud flats at low tide.

Etymology. The new subspecies is named for Elodie Vulliet of Arundel, Gold Coast, Queensland, Australia, granddaughter of the well-known Australian-New Caledonian shell dealer, Thierry Vulliet. Mr. Vulliet supplied us with the type lot and asked us to honor his granddaughter, a budding malacologist, with the new name.

Discussion. The northern Queensland *Viduoliva westralis elodieae* differs from the Western Australia and Northern Territory *V. westralis westralis* (Petuch and Sargent, 1986) (Figure 1G & H) in being a smaller and much more inflated shell, being much less elongated and less cylindrical in profile, in having less straightened and more rounded sides, and in being a more colorful shell, with brighter yellow and green colors on the body whorl. Both subspecies exhibit a bright golden orange color form, but these occur much more frequently in *V. westralis elodieae* than they do in *V. westralis westralis* (around 10%-15% of individual specimens of *elodieae* exhibit the golden color: S.J. Maxwell, personal communication). The absence of *Viduoliva westralis* in the southern Gulf of Carpentaria demonstrates that there is a substantial geographical separation between the two subspecies, allowing for genetic drift.

ACKNOWLEDGMENTS

We thank Thierry Vulliet of Arundel, Gold Coast, Queensland, Australia for the generous donation of specimens of the new subspecies for scientific study. We also thank Gregory Curry, Key West, Florida, for taking the photograph of *Viduliva westralis* used on the plate.

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- Petuch, E.J. and D.M. Sargent.** 1986. *Atlas of the Living Olive Shells of the World*. The Coastal Education and Research Foundation, Fort Lauderdale, Florida. 253 pp.



Figure 1. *Viduliva westralis* and its Subspecies. A, B = *Viduliva westralis elodieae* Petuch and Berschauer, new subspecies (golden color morph), holotype, length 39.1 mm, QM MO85815, low tide on muddy sand, Port Douglas, Queensland, Australia; C, D = *Viduliva westralis elodieae* Petuch and Berschauer, new subspecies, length 42.4 mm, Port Douglas, Queensland, Australia (transitional color form from green to golden); E, F = *Viduliva westralis elodieae* Petuch and Berschauer, new subspecies, length 41.5 mm, Port Douglas, Queensland, Australia (typical green color form); G, H = *Viduliva westralis* (Petuch and Sargent, 1986), length 49.0 mm, found on a sand bar at low tide, off Broome, Western Australia.



Have a shell collection you would like to donate to The San Diego Shell Club?

The San Diego Shell Club is interested in your shell collection. As a 501c(3) organization, all donations to our Club may provide a tax write-off. When we receive a donation we provide a letter describing the items that may be used when filing your taxes. While we cannot provide a value, donations of up to \$5,000 do not require a written appraisal. Since tax laws change regularly we recommend that you check with your tax accountant before relying on any information provided here.

We are interested in all types of shells, marine or land and all genera and species, including books on shells as well as items related to shells such as artwork, storage cases and tools. Your donated items will be used to generate income to support the Club's efforts in continuing Public education about shells and conservation of marine life throughout the world. If you would like to donate, please contact David Waller, SDSC Acquisition Chairperson, at dwaller@dbwipmg.com to schedule a time to discuss charitable gifting.

CLUB NEWS

2018 November General Meeting and Fall Auction

See article on page 74.

2018 Holiday Party

Our annual holiday party was held on December 8, 2018, at Leo Kempczenski's home in Tustin. We had a good turn out with members from three counties present. There was catered BBQ food from Lucille's, beverages, our secret gift exchange, and lots of shells to share, trade and sell. A good time was had by all.

2019 January General Meeting

Our January general meeting held on January 26, 2019, at Sylvana Vollero's home in San Diego. The speaker was David Berschauer who gave a fascinating presentation on Ficidae, the fig shells. We had a good turn out with over a dozen members present and a wonderful spread of dishes provided by members. There were also shells for show, trade and sale.

President's Message

LisaDawn Lindahl
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Thank you San Diego Shell Club for welcoming me on board as President of the Club for 2019. What an honor! I've been very privileged to meet many of you during these past 4 years and I sincerely look forward to meeting many more of you.

Moving into 2019, I'm afraid my predecessor left quite a hard act to follow! Dave Waller and the crew from SDSC accomplished much in 2018, including the publication of several amazing books, the 3rd annual West Coast Shell Show ("WCSS"), and hugely successful COA Convention. All of this contributed to our prosperous and continuously growing shell club. To all of you who helped us continue being a premier organization; congratulations, you rocked it!



New goals for our Club include: strengthening our online presence by using Skype (or similar) for our general meeting presentations, in the hope of achieving a more personal connection with our global members; working to introduce shell collecting for children by having in class presentations on malacology and ocean environmental issues at schools/ learning institutions; and setting up a SDSC display table at local street fairs to introduce the general public to the field of Malacology.

Having secured a larger room this year for the 4th annual WCSS allows us to provide more space for exhibitors, dealers, and world class presentations in the field of Conchology. We will also be promoting more Shell Arts by local artists, with the opportunity to exhibit, compete and sell. Work is underway in designing a free coloring book for children visiting the WCSS, so that we can have a table set up to color at during the shell show. In keeping with our tradition we will be giving a free shell to all children under age 13, with a quick shout out to Grandpa Buck for his work with the kiddos at this annual event.

In conclusion, let's keep those marvelous articles coming for Festivus. The hard work and dedication that goes into our SDSC quarterly publication has given our Club something to boast about thanks to you! Honorary members as well as newbies, we would not be the great Club we are without your input and experiences.

Happy shelling in 2019, and thank you again.

LisaDawn Lindahl

A Trip to Curaçao and Aruba

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After our recent 20 days trip to the A and C of the ABC Islands, several collectors asked about our experience. We did not go to the B island (Bonaire), because a place where they tell you not to pick up shells from the beach is not for us. The following is a report on our observations on the marine fauna, and we will give a brief comparison of the two islands from our personal perspective. The moderately short duration of our stay did not allow our visiting all of the sites that we had heard of, but we nevertheless, were determined to take a tour with the famous submarine "Curasub".

Curaçao

In Curaçao, we stayed in the Kura Hulanda Resort (Arrow 1 on the map in Figure 1) at the northwestern tip of the island. We had been warned by the consistently negative ratings on TripAdvisor. Indeed we had the pleasure of experiencing the mediocre quality of food and service, the lousy maintenance of the resort, and an endless number of other shortcomings that guests before us had described. The resort is in deep financial trouble and basically lacks a manager and funding. Nevertheless, we thoroughly enjoyed the lovely scenery and the easy diving on the house reef in the front of the resort. The gentle underwater slope is beautiful: covered in sponges and coral, a few gorgonians, and dropping to 120 feet. Unfortunately, there is a remarkable absence of larger fish and the invertebrate diversity is the lowest that we have seen anywhere in the world.

Finding dead shells of any species was hard; from the very shallow parts close to the beach down to 100 feet, there was basically nothing. Normally we do not turn over anything and do not take live shells when Scuba diving. The rocks and coral slabs we did check were on silty sand, very little growth, and basically no other marine life under them. This was observed in the shallow area in the bay in front of the resort, and also in the deeper areas beyond the drop-off. Dive sites further north had fantastic reefs (*e.g.* "Watamula"), and further south, the diversity of corals and sponges was greater ("Mushroom Forest"). However, all places visited on Curaçao were basically devoid of shells. On a total of 18 dives (which means one and a half days under water between the two of us) we found three fresh dead *Tenorioconus aurantius* (Figure 2) at 15 to 40 feet shown in the picture below.



Figure 1. Map of the "ABC islands."

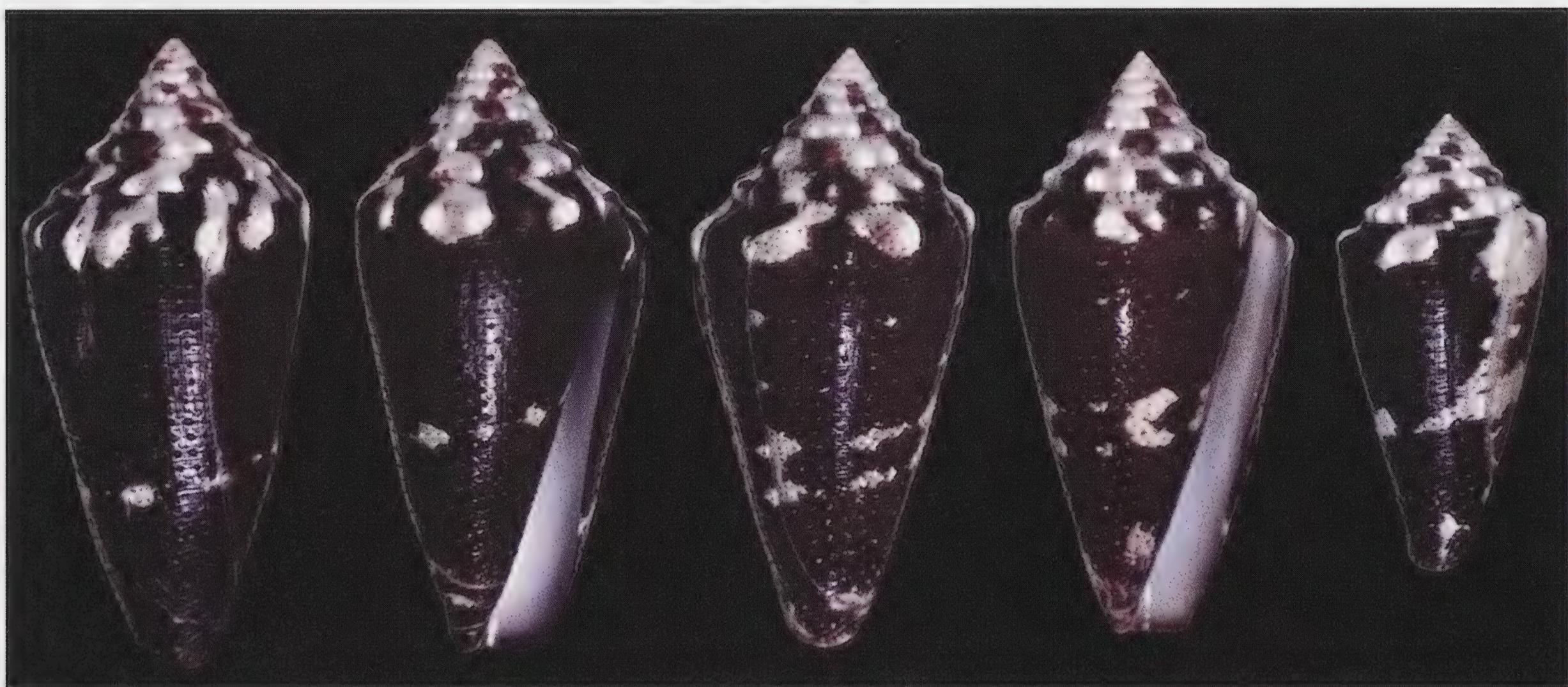


Figure 2. *Tenorioconus auratinus* (Kura Hulanda House Reef, Curaçao), largest shell is 57 mm.

There are numerous diving schools, and tank fills (including Nitrox) are rather inexpensive. On Curaçao, you can rent tanks to take with you, which is what many divers do. The slopes or drop offs to deeper water are usually close to the shore and road signs point to suitable dive sites. We encountered either non-existent or very little current, and the visibility was great once you got past the shallows, and a wetsuit was not required.

The only beaches on Curaçao that produced a few shells were the strip at Playa Grande just south of Kura Hulanda, a tourist hot spot for watching sea turtles attracted by fishermen cleaning their catch. The second place shells had washed ashore was on a rubble beach west of Santa Martha (Arrow 2 on the map in Figure 1). When arriving at the beach, you have to swim from the abandoned building across a narrow channel. The beach on the opposite side stretches for about one mile and yields rather acceptable *Atlanticonus granulatus*, *T. aurantius*, *Voluta musica*, and *Cypraecassis testiculus*, but make sure you arrive at low tide. Interestingly, while diving in Curaçao we saw only one living, adult Queen Conch, *Lobatus gigas*, but many fresh dead "rollers" of approximately 5". Something seems to have killed an entire generation of the young Strombidae.

We also took the dayboat to Klein Curaçao, a small sandy island one hour offshore to the east (Arrow 4 on the map in Figure 1). This was a nice touristy trip with an excellent BBQ, and yet again, no shells among the garbage on the beaches away from where they dump the tourists.

Next, we moved to Jan Thiel in the south of Curaçao, straight across from the Aquarium and the Substation (Arrow 3 on the map in Figure 1). Together with



Figure 3. Curasub submarine at Curaçao.

Barbara and Bruce, who operated the submarine venture (Figure 3), we soon found ourselves at 600 to 900 ft., soundlessly gliding along rocky drop-offs and rubble fields inhabited by bizarre sponges, crinoids, crabs, and fish that we had never seen before. There were some crabbed cones and quite a few *Onustus caribaeus*. Yes, and a few slit shells sitting on ledges or in crevices of the rocks.

We had permission to collect a few samples for the Molluscan Science Foundation, Inc., and came up with a few *Dauciconus sorenseni* (Figure 14), *D. perprotractus* (Figure 14), *Isara antillensis*, *Perotrochus sunderlandorum* (Figure 4), *Entemnotrochus adansonianus* (Figure 4), *Sconsia clarkii*, and a *Dentalium* inhabited by a hermit crab modified to close the aperture of the tusk (Figure 19). On our second dive, the pump sucking in samples did not work, so we scooped up grit from 900 feet with the net at the front of the submarine. Apart from a few interesting bits, this exercise turned out fairly poor results. In any case, the submarine dives were an expensive, yet unforgettable, experience.

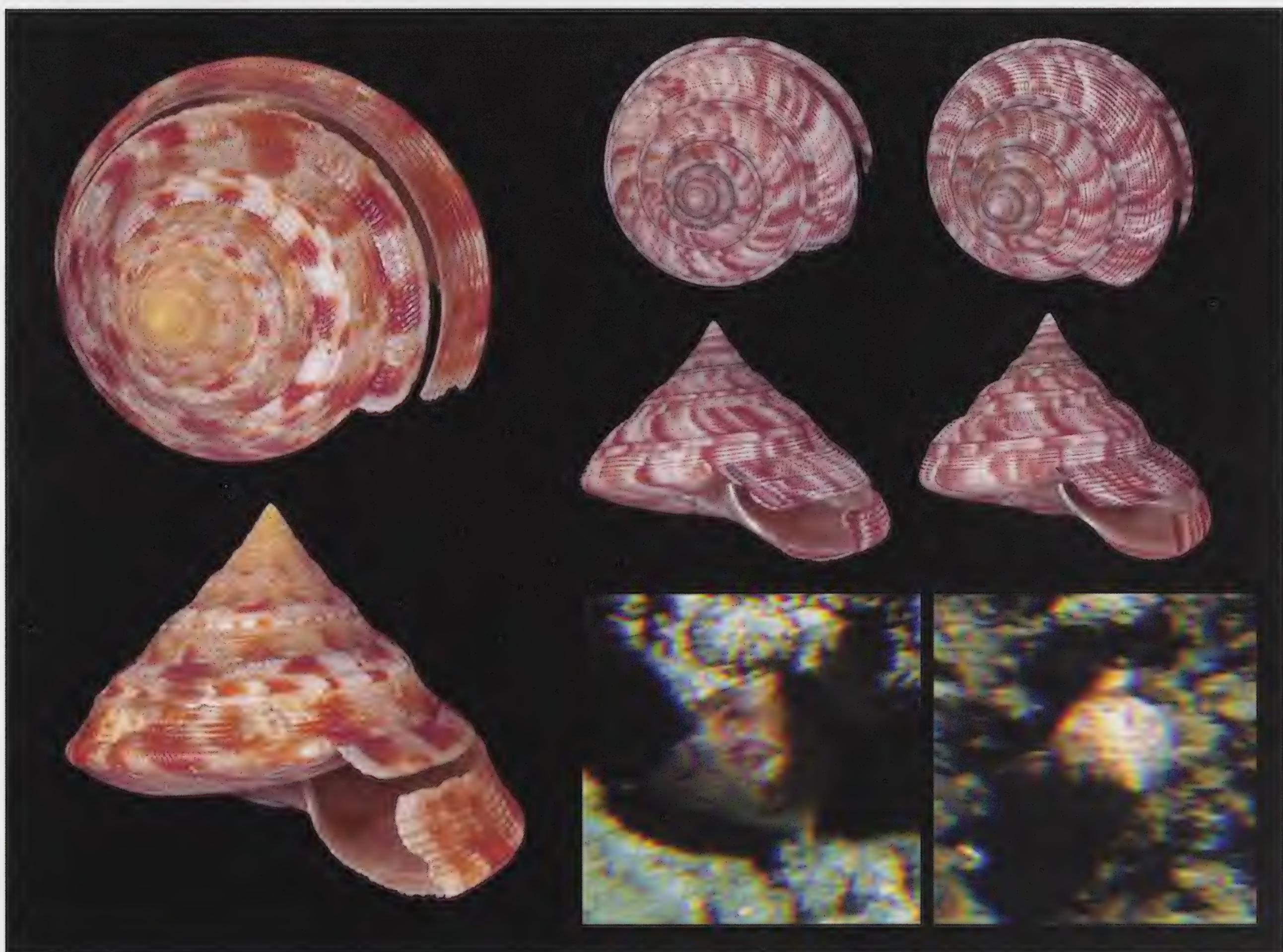


Figure 4. Left: *Entemnotrochus adansonianus* (Curaçao, at 600 ft, 64 mm; middle and right: *Perotrochus sunderlandorum* (Curaçao, at 800-900 ft, 44 and 46 mm). Other shells found in Curaçao are shown in Figures 9-11, 15 and 19.

Aruba

As a preparation for Aruba, we tried to make contact with those local collectors we knew. Some did not even respond to our e-mails, others gave a friendly hint that they were not prepared to share any information. Our policy is that anybody willing to travel far and put an effort into responsibly collecting shells should be welcome to go where they want; to experience how hard or easy collecting is at travel destinations. So, we will tell you exactly where we found shells on Aruba. Our place was a cozy beach house north of the big hotels of Malmok (Arrow 5 on the map in Figure 1). Felix had read the name "Hadicurari Beach" on a 1970s label that came with a bag of worn *Tenorioconus curassaviensis*. We were so delighted that right in the front of our accommodation, we could pick up fairly nice specimens of this pretty cone up from the beach (Figure 6). The area where fresh shells are cast ashore is single strip of beach spanning approximately one mile between the Casino and Boca Catalina Beach, along the L.G. Smith Boulevard. There are a few patches with nice microshells and marginellids that can be found further north. Every morning of our six-day stay at Aruba, Felix walked up and down that beach, shoving away those godless barbarians traipsing straight through the fresh beachgrit. Terrible ignorants. They are everywhere!



Figure 5. Marginelliform species. Scale: 10 mm; 1, 2: *Persicula calculus* (Aruba); 3: *Persicula muralis* (Aruba); 4: *Gibberula pulcherrima* (Curaçao); 5: *Gibberula catenata* (Curaçao); 6: *Persicula* sp. (Curacao); 7: *Volvarina* sp. (Aruba); 8: *Persicula chrysomelina* (Aruba); 9: *Persicula* sp. (Curaçao).

As nobody was kind enough to tell us that we could legally collect shells, we had to find out by ourselves and to finally pick up a few nice *Arubaconus hieroglyphus* (Figure 7) and several other species. The best place to snorkle is in the front and to both sides of a rusty wreck that is visible from the road along Hadicurari Beach. It is easy to access from the shore, and there are numerous different shallow water habitats to investigate. In contradistinction to Curaçao, the invertebrates found in Aruba are rich, and every small rock you turn has brittle stars, crabs, sponges, small and large bivalves, and sometimes, hundreds of tiny hermit crabs carrying a great variety of microshells. There

are also more fish and turtles as soon as you snorkle out half a mile. Even close to shore, every second rock pool has a *Voluta musica*, if you have the patience to fan the sand all the way down and wait another three minutes for the dust to settle. We found mainly subadult ones and those that were adult had an eroded top, so finally we left them all behind. Generally, snorkling in the shallow water along Hadicurari Beach will produce a variety of cones, usually crabbed but well-preserved, including *Jaspidiconus arawak* (Figure 8), *J. bootii*, *Perplexiconus columba* (Figure 8), *Tenorioconus curassaviensis* (Figure 6), and some others.



Figure 6. *Tenorioconus curassaviensis* (Hadicurari Beach, Aruba), largest shell is 31 mm.



As for cowries, *Luria cinerea* can be observed, mostly in pairs, under larger coral slabs in the shallow water, and a few *Naria acicularis*, in deeper areas. Adult *Lobatus gigas* are quite common as soon as you snorkel out a bit, while rollers are abundant in the muddy areas just along the shoreline.

There are other places on Aruba where snorkeling can produce some nice material, e.g. the south coast along Barcadere and Mangel Halto, but if the wind is too strong and coming from the sea, the water gets milky, which was the case the day we visited these places. Another interesting place for shells is at the opposite end of the island around a small bay called Baby Beach. East of that touristy place (avoid the "Big Mama Grill"), there is an animal cemetery and a really productive beach.

Figure 7. *Arubaconus hieroglyphus* (Aruba) Largest shell: 21 mm.

Scuba diving from the beach is not possible in most places in Aruba, as the drop off is too far out. Therefore, we refrained from wasting a whole day getting onto a boat, doing two dives, and heading all the way back to shore. As the diving on Curaçao became boring very quickly, we probably did not miss much by not diving on Aruba anyway. Other shells found in Aruba are shown in Figures 5, 12, 13, and 15.

In conclusion, Aruba was much richer in shallow water marine fauna and shells, while Curaçao apparently has seen better days, reflected by a lot of dead coral in the shallow water, and lots of subfossils, but hardly any fresh shells. Both islands have a wonderful, laid-back, and welcoming population. However, where is the wealth supposedly taken into these small nations by all the city-sized cruise ships that come and go every day? The ferry terminals are lined with luxurious shops, jewelry stores, fancy restaurants, as well as all of the big names and franchises, but as soon as you move three roads inland, you will find run-down homes, bad roads, a dilapidated infrastructure, and abandoned office buildings.

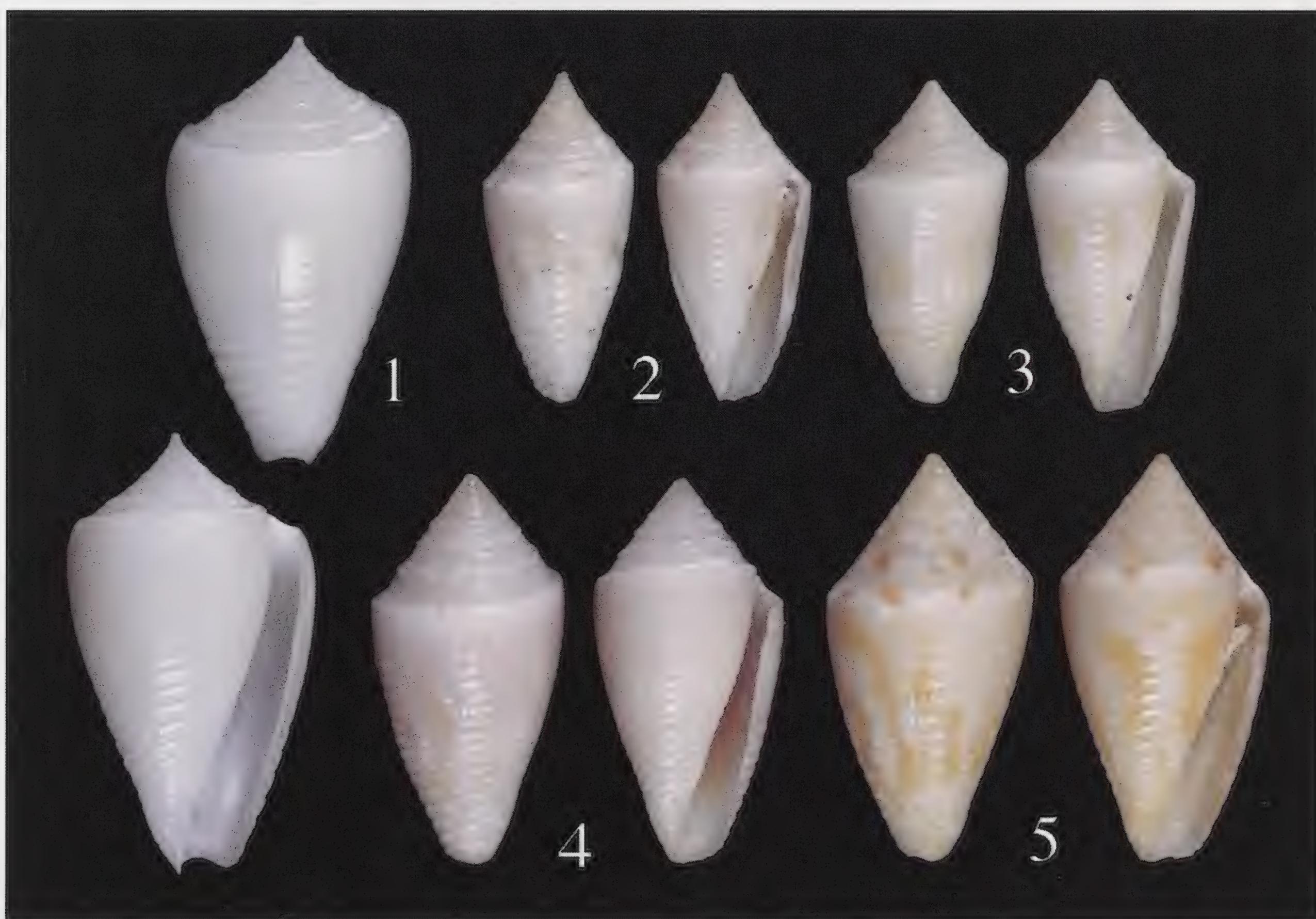


Figure 8. Conidae from Aruba. 1: *Perplexiconus columba* (21 mm); 2, 3: *Jaspidiconus arawak* (16 and 17 mm); 4, 5: *J. bootii* (19 and 22 mm), all from Hadicurari Beach, Aruba.

Entering and leaving the countries is fast and efficient. Only the “Rent A Car” facility at Curaçao made it hard by taking nearly two hours to give us our rental. We noticed a difference from other tropical places, as people on A and C are attentive and considerate drivers. Caribbean flair and beautiful, seemingly untouched areas could be found on both islands, but the rocky shore at the lighthouse of northern Aruba stuck out. As everywhere on this planet these days, exposed beaches not frequented by tourists are full of plastic waste. The stories we heard about holdups, cars being broken into, stuff being stolen from hotel rooms, etc. did not turn out to be true for us. This is especially true for Curaçao, which has taken measures against its bad reputation, e.g. by placing security personnel in parking lots along the beaches. For the accommodation, the rates given locally are sometimes twice as high as rates given over the internet on the same day. In both places, you need a rental car or motorbike to get around. The stores offer a surprising range of food and drinks, and on both islands you can pay with U.S. dollars. The water from the tap is of excellent drinking quality, so no need to buy plastic bottles with water. There are no conch fritters served anywhere on Aruba or Curaçao. To fuel up, you need cash, but most other places accept credit cards. You definitely need mosquito repellent and lots of it.



Figure 9. *Columbella mercatoria* (1st and 2nd row: Curaçao, 3rd row: Aruba), largest shell is 14 mm.



Figure 10. *Isara antillensis* (Curaçao, at 750 ft, 40 and 75 mm).



Figure 11. *Spondylus americanus* (Playa Grandi, Curaçao) with pearl attachments (58 mm).



Figure 12. Turrids and similar. Scale: 10 mm. 1: *Mitromorpha dormitor* (Mitromorphidae); 2: *Splendrillia vinkii* (Drilliidae); 3: *Tenaturris inepta* (Mangeliidae); 4: *Tritonoharpa* sp. (Cancelariidae). All from Aruba.



Figure 13. *Oliva fulgurator bulla* (Hadicurari Beach, Aruba), largest shell is 42 mm.

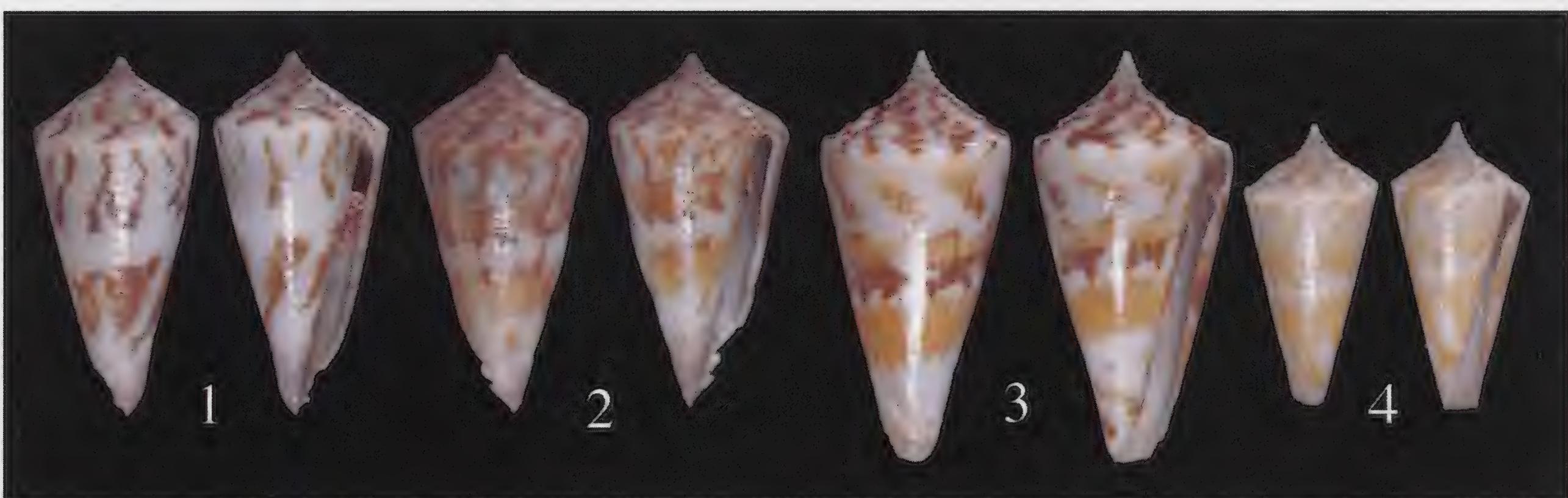


Figure 14. Conidae from deep water. 1, 2: *Dauciconus perprotractus* (Curaçao, at 750-900 ft, 30 and 29 mm); 3, 4: *Dauciconus sorenseni* (Curaçao, at 700-900 ft, 40 and 24 mm).



Figure 15. Triviidae. Scale: 10 mm; 1: *Pusula pediculus* (Aruba); 2: *Pusula* sp. (Aruba); 3: *Niveria suffusa* (Curaçao); 4: *Cleotrivia antillarum* (Aruba); 5: *Niveria quadripunctata* (Aruba); 6: *Niveria nix* (Curaçao).



Figure 16. *Dentalium* sp. with peculiar hermit crab (Curaçao, at 750 ft, 100 mm).

Acknowledgements:

Many thanks to Professor Edward J. Petuch and Dr. Peter Stahlschmidt for identification help, and to Dr. Michael A. Mont for proofreading.

Lines in the Sand - Toward an understanding of the *Lindaconus* species complex

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This article is as much a review of *Lindaconus* species in the Carolinean Province and the Caribbean Province as an examination of the philosophy of molluscan systematics. I am going to opine briefly on the philosophy of our field of science first, as that will set the stage for looking at these remarkable cones.

When we talk about a “species,” what is it we are really saying? There are more than a dozen “species concepts” used in biology, although perhaps fewer in paleontology as they can only work with fossils rather than organisms living today. Not all of these species concepts are equally useful as organisms often have vastly different reproductive and life cycles, *i.e.* parthenogenesis, budding, and other modes of asexual reproduction. Before we get to the hypothetical “species,” which is a hypothesis or theory advanced to explain what we believe we see in nature, what we really observe are individual organisms. A “species” is not a thing. From looking at individual organisms, we can postulate a hypothetical population of such organisms living at a given time in a habitat comprised of three dimensional space; often in the case of sexually reproducing organisms we are hypothesizing a “breeding population.” In the case of shells, we are seeing the dead exoskeletons of soft bodied mollusks, and as a consequence often times the researcher has never seen the living animal.

When the researcher is merely dealing with a dead shell often it is not too terribly different from a paleontologist dealing with a fossil shell. Looking at one individual shell you can make comparisons to other individual shells in your possession that may be compared and contrasted to another “known group” of individuals. That other “known group” of individuals have already been “named,” meaning that someone has previously published a species hypothesis defining the parameters of a hypothetical population of individual organisms that may exist or may have existed at a certain point in the four dimensions of time and space. Looking at a number of shells allows you to observe morphological similarities and differences between individuals, and if you observe what you believe are significant similarities in that group, which are different from other such groups you can use abductive reasoning to frame a species hypothesis. This is the time honored method by which the vast majority of species hypotheses have been made for the past 300 years and has worked equally well for living organisms and fossils. The researcher should always use all the evidence at hand or reasonably available to explain the variability observed. Besides morphology, other tools available in the understanding of organisms include a study of their distribution, habitat, ecology, anatomy, radula morphology, molecular studies (such as mitochondrial and nuclear DNA), and so on. Many of these tools are not available to the paleontologist as the soft body parts are no longer available for study.

So why does it matter? One of the more important reasons why we name organisms is so that we can discuss them. Without having a name for a perceived group of similar looking organisms it is

extremely difficult to discuss them, to discuss their habitat, reproduction, what and how they eat, their depth range, or to define the parameters of their biogeographical distribution. All of these factors are also important to look at and use in the abductive reasoning process which we use to define a species hypothesis.

Clearly, the field of systematics is to some degree arbitrary. The hierarchical system including superfamily, family, subfamily, genus, subgenus, species (and in some cases subspecies), really involves judgment calls that can be questioned, debated, or argued by others. No matter what taxa level, it is all really someone's hypothesis, namely "a line in the proverbial sand" that is subject to change over time based upon the opinions of others. Where to draw that line, and when, is often the subject of intense disagreement. So why do we care, and what are these lines in the sand supposed to tell us? We care because the purpose of the science is to explain the variability that we observe in nature, to help us understand the world around us - the one that we live in today, and the one that existed in the distant past. Each of these groupings of higher taxa are meant to, and should always, help us group "species" in such a manner as to show their similarities to one another, and to demarcate their differences from other such groups. Where these lines are blurred or removed we lose information, and we lose an explanation of those similarities and differences. In this way it is often said that it is better to make a hypothesis and to name a species or higher taxa than to not do so, because the attempt to explain the variability that we observe in nature has value in and of itself. Further, those groups can always be brought back together again by a later researcher who sees more similarities than differences and publishes a subsequent study, setting forth a hypothesis combining taxa previously named by others. The researcher should act with purpose and avoid taxonomy by fiat.

That brings us to the genus *Lindaconus*, an interesting group of spotted cone shells, Conidae, found living today throughout the Carolinean and Caribbean Provinces. The individual shells which are illustrated in this paper are typical specimens of various species hypotheses that have been previously named in the genus *Lindaconus*; this paper is not a taxonomic work. Each of these seven species, named between 1791 and 2013, has a distinctive morphology, habitat, and biogeographical distribution. For more information on this see Vink 1985, Tucker 2009, and Tucker 2010. In order of the date when they were named, there are seven living species of cones in the genus *Lindaconus*:

- L. spurius* (Gmelin, 1791)
- L. lorenzianus* (Roding, 1798)
- L. baylei* (Jousseaume, 1872)
- L. phlogopus* (Tomlin, 1937)
- L. atlanticus* (Clench, 1942)
- L. linda* Petuch, 1987
- L. therriaulti* Petuch, 2013

These are the seven taxa that have been placed by various authors into the genus *Lindaconus*, and which share a number of features in common - the most obvious of which is that they are all relatively large white cones with spots. It is important to note that the larva of *Lindaconus* can only swim for a few minutes to a few hours before settling. (Leal *et al.*, 2017); this means that dispersal is limited. Some researchers have combined many of these species under the name *L. spurius* (Gmelin, 1791) with little to no analysis or explanation of their reasoning, merely because they could see no

differences and because *L. spurius* was named first. Other people have set forth a reasoned analysis why they believe that one or more of these taxa belong together, such as the southern species *L. lorenzianus* (Roding, 1798) and *L. phlogopus* (Tomlin, 1937), or the nominate species *L. spurius* (Gmelin, 1791) and *L. atlanticus* (Clench, 1942); note the characteristic two bands of flammules on the body whorl of *L. spurius* is one of the most readily observable distinguishing characteristics.

The following biogeographical map (Figure 1) is included for illustrative purposes as it shows the known distribution of each of the seven living species of *Lindaconus* as follows:

L. spurius (Gmelin, 1791)

Antillean & Northern Grenadian Subprovinces
and Yucatan to Panama, rarely in N. Cuba & Bahamas

L. lorenzianus (Roding, 1798)

Central and south Nicaraguan Subprovince

L. baylei (Jousseaume, 1872)

Central Venezuelan Subprovince to Aruba

L. phlogopus (Tomlin, 1937)

Western Venezuelan Subprovince

L. atlanticus (Clench, 1942)

Carolinean Province

L. lindae Petuch, 1987

Deep water Bahamian Subprovince

L. therriaulti Petuch, 2013

Campeche Banks of Yucatanean Subprovince



Figure 1. Biogeographical Distribution of *Lindaconus* species. Orange = Carolinean Province, *L. atlanticus* (Clench, 1942); Red = Cortez Banks of the Yucatanean Subprovince, *L. therriaulti* Petuch, 2013; Dark Green = Deep waters of the Bahamian Subprovince adjacent to the continental coast of Florida, *L. lindae* Petuch, 1987; Yellow = Antillean & northern Grenadian Subprovinces, and Purple (Yucatan to Panama), *L. spurius* (Gmelin, 1791); Purple = Central and lower Nicaraguan Subprovince, *L. lorenzianus* (Roding, 1798) and *L. spurius* (Gmelin, 1791); Dark blue = Western Venezuelan Subprovince, *L. phlogopus* (Tomlin, 1937); Gray = Central Venezuelan Subprovince to Aruba, *L. baylei* (Jousseaume, 1872).

The majority of these seven species are distributed along the continental coastlines, with the exceptions being *L. spurius* (Gmelin, 1791), which is found off shore along the coastlines of the north and central Caribbean islands, and *L. lindae* Petuch, 1987, which is only found in the Bahamian Subprovince in deep waters adjacent to the continental coast of Florida (Petuch, 2013). For ease of reference I have arranged illustrations of these seven taxa on two plates, roughly divided into northern species (Carolinean Province and North-Central Caribbean Province) and southern species (Central-South Caribbean Province).



Figure 2. Northern *Lindaconus* species. A-C = *L. atlanticus* (Clench, 1942) [A and B = 51.5 mm, C = 30.0 mm]; D-F = *L. spurius* (Gmelin, 1791) [D = 29.9 mm, E and F = 31.8mm]; G-I = *L. lindae* Petuch, 1987 [G and H = 31.0 mm photo of Holotype courtesy of A.J. Kohn from Biology Burke website, I = 41.0 mm original photo courtesy of Tom Honker]; J-L = *L. therriaulti* Petuch, 2013 [J = 54.5 mm, K and L = 43.0 mm photo of Holotype courtesy of Dennis Sargent from The Cone Collector website]. Figures C, D, G, H, I, J, K, and L by J.K. Tucker with permission. Figures E and F by A. Medvedev from Wikipedia with permission.

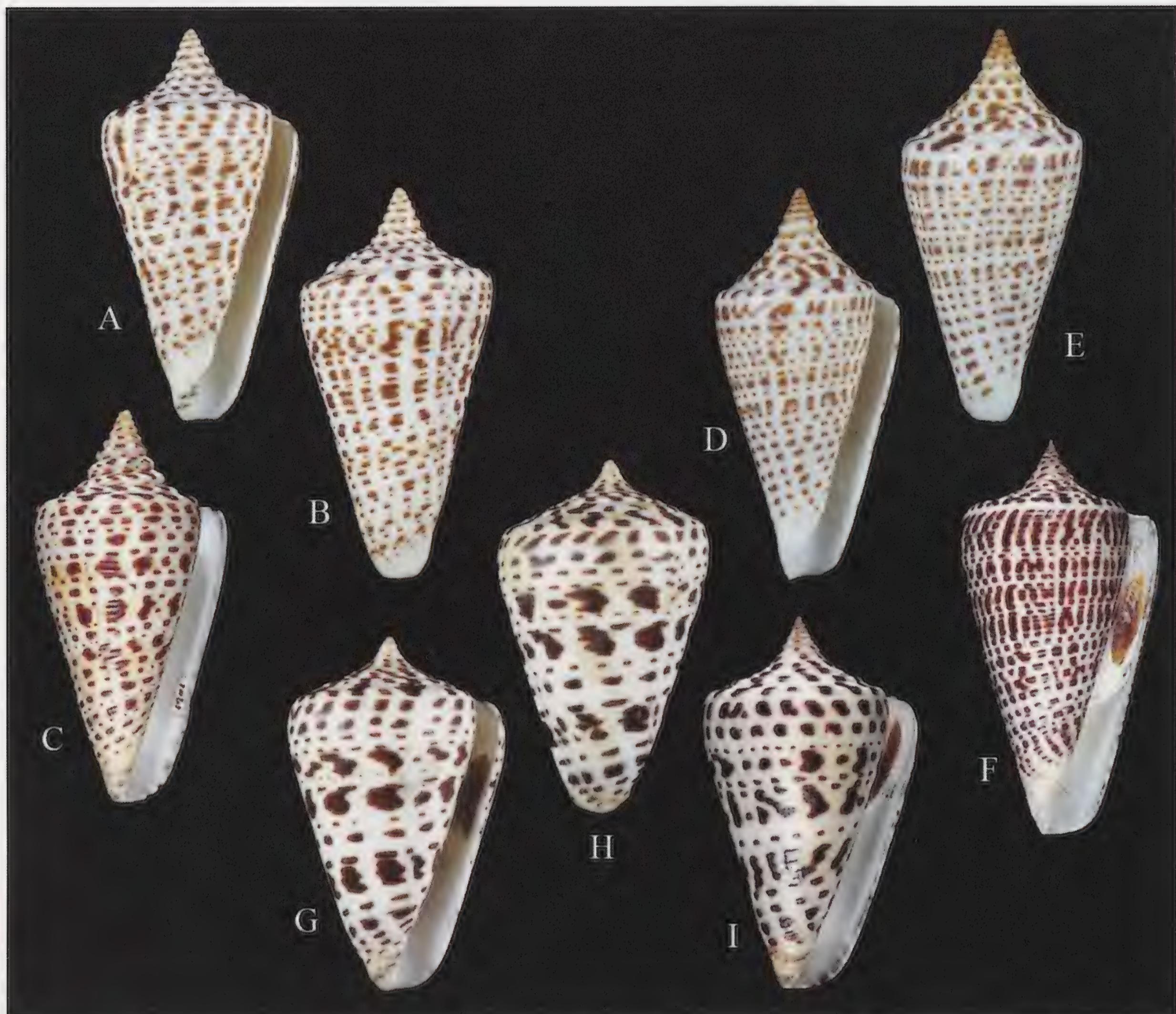


Figure 3. Southern *Lindaconus* species. **A-C** = *L. lorenzianus* (Roding, 1798) [A and B = 58.9 mm, C = 50.9 mm]; **D-F** = *L. phlogopus* (Tomlin, 1937) [D and E = 42.4 mm, F = 51.5 mm]; **G-I** = *L. baylei* (Jousseaume, 1872) [G and H = 69.9 mm, I = 49.8 mm]. Figures C, F and I by J.K. Tucker with permission.

ACKNOWLEDGMENTS

Special thanks to John K. Tucker, Paul Kersten (The Cone Collector), and Alexander Medvedev for permission to use images, Edward J. Petuch for discussions regarding biogeography of these cones, and to Daniel Geiger and Kirk Fitzhugh for discussions about the philosophy of systematics.

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November General Meeting and Auction

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Once again, the November General Meeting and Auction was graciously hosted by David and Felicia Berschauer at their home in Laguna Hills, California. About 20 members turned out for the auction with many of the usual suspects and a couple new members attending for their first time. The auction was a pot luck event and the food was terrific. David and I were the auctioneers and everyone had a great time. Some notable auction items were a *Cypraea leucodon* that sold for \$400, *Zolia roseopunctata* sold for \$300 and *Cypraea rosselli* that sold for \$240. A special thanks to David and Felicia for hosting this event.

This year's November auction was a great success! Thank you to David Berschauer, Lisa Lindahl, Leo Kempczenski, Larry Buck and Bill Schraam for all of their help in organizing and setting up the auction. Historically, SDSC auctions brought in about \$2,000-\$2,500 income per year, which helped to defer the publication costs of *The Festivus* (now the publication of *The Festivus* is paid solely through membership fees). In the past couple of years, the Club began holding two auctions annually and increased the number of specimen shells from popular shell families. This increased the Club's income to approximately \$6,000 to about \$7,000 per year. With the purchase of the Pratt collection in 2017, the SDSC was able to obtain about \$10,500 in that year, the highest income ever recorded for our Club. Even though some of the regular attendees were not present, the 2018 November auction brought in more than expected tipping the scales at \$4,400 making the Club's total income for 2018 auction sales about \$8,500. Thank you to all the members who attend our auctions for their support.



Figure 1. Collage of live auction shells.

The General Meeting started with heartfelt thanks for all of those members that helped in an event filled and challenging 2018. This list of individuals was long and I did my best to recognize everyone by name. What was really exceptional was the commitment our Club demonstrated in hosting the COA convention. I pride myself in giving 150% to any and all projects that I invest my time in accomplishing. However, I do not project that obsessive and compulsive behavior on to others. Well, I was impressed to find our Club members giving 200% and more to the COA convention tasks they were assigned. I congratulate all of you on a job well done. The COA convention was a great success not only for the hospitality that the SDSC Club provided to the guests, fantastic presentations, great specimen shells for the auctions, variety and quality of specimen shells at the bourse, and the time spent by our community of shell collectors catching up on the past years events, but because this

COA, while not having the greatest attendance, brought in the second highest income from the silent and verbal auctions in the history of COA. For this, the San Diego Shell Club should be proud. A special thanks to the following SDSC members (listed in alphabetical order):

Marty Beals (Donor, Auction Co-Chair)
David Berschauer (Co-Chair, Presenter, Author "Seashells of Southern California")
Hank Chaney (Donor, Auctioneer)
Roger Clark (Assistant, Presenter, Author "Seashells of Southern California")
John D. Daughenbaugh ("Duffy") (Donor, COA Convention Treasurer)
Nancy Hale (Registration Chairperson)
Paul Kanner (Presenter, Author "Treasures of the Sea")
Dr. Murray Kaufman (Donor, Presenter, Author "Treasures of the Sea"))
Leo Kempczenski (Assistant)
Julian Lee (Donor, Auction Chairperson)
Lisa Lindahl (Creator of the COA 2018 Convention logo and poster, Banquet Chairperson)
Dr. Edward Petuch (Presentation Chairperson)
Don and Jeanne Pisor (Donors, Bourse Chairperson and Welcome Dinner Chairperson)
Bill Schramm (Assistant)
Jill Spofford (Assistant)
Dr. Paul Tuskes (Field Trip Chairperson)

Most of the San Diego Shell Club Presidents serve two terms. While I was honored to be asked to serve a second term, I felt it was time for some of our newer members to take the helm and steer this ship through 2019 and into the future. I was pleased when Lisa Lindahl said that she would consider my recommendation as Captain and knew she was the right person when I was informed that she had already chosen a crew to serve under her command. Please welcome our new Board for 2019: Lisa Lindahl President, Jill Spofford Secretary, Nancy Hale Treasurer, David Berschauer Vice President and I will continue to serve as Past President. As I leave the Presidency, I would like to wish all of our members a Happy and Prosperous New Year!



Figure 2. Readyng the live auction tables.



Figure 3. Jill Spofford examining a coral specimen.



E. adansonianus adansonianus (Crosse & Fischer, 1861), Bahamas, 106.1 mm. *B. poppei* (Anseeuw, 2003), Tonga Islands, 58.8 mm. *P. amabilis* f. *maureri* Harasewych & Askew, 1993, USA, 42 mm. *B. tangaroana* (Bouchet & Métivier, 1982), New Zealand, 55.9 mm. *P. quoyanus* (Fischer & Bernardi, 1856), Curaçao, 50.7 mm. *B. philpoppei* Poppe, Anseeuw & Goto, 2006, Philippines, 65.1 mm. *B. charlestoniensis* Askew, 1987, Martinique, 77.3 mm. *B. midas* (Bayer, 1965), Bahamas, 82.7 mm.

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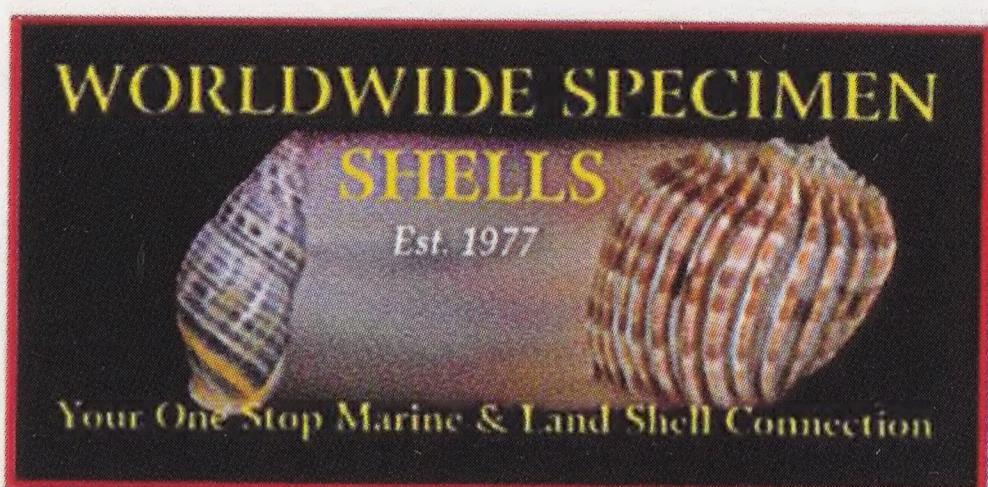
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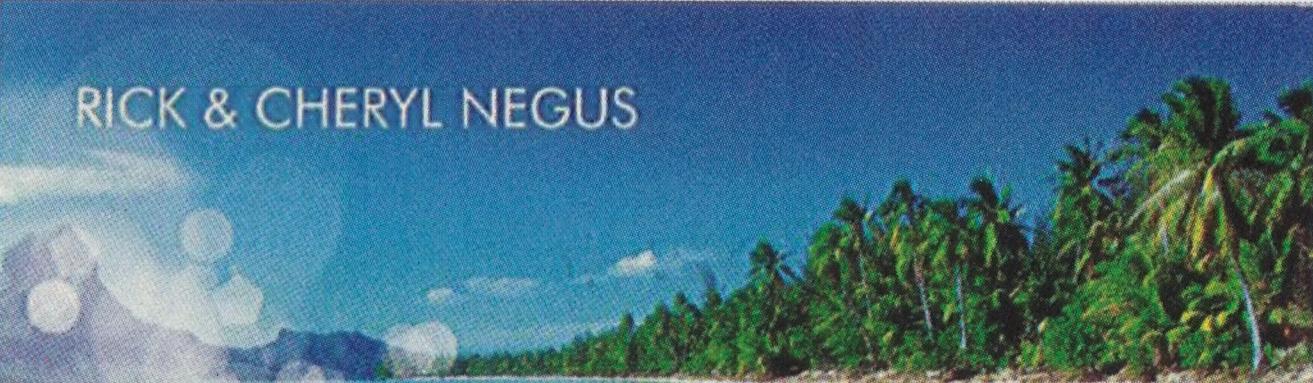
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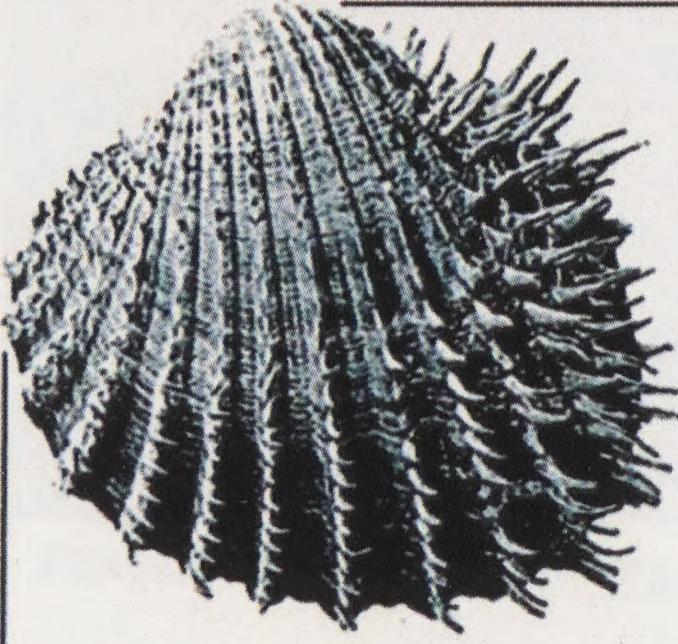


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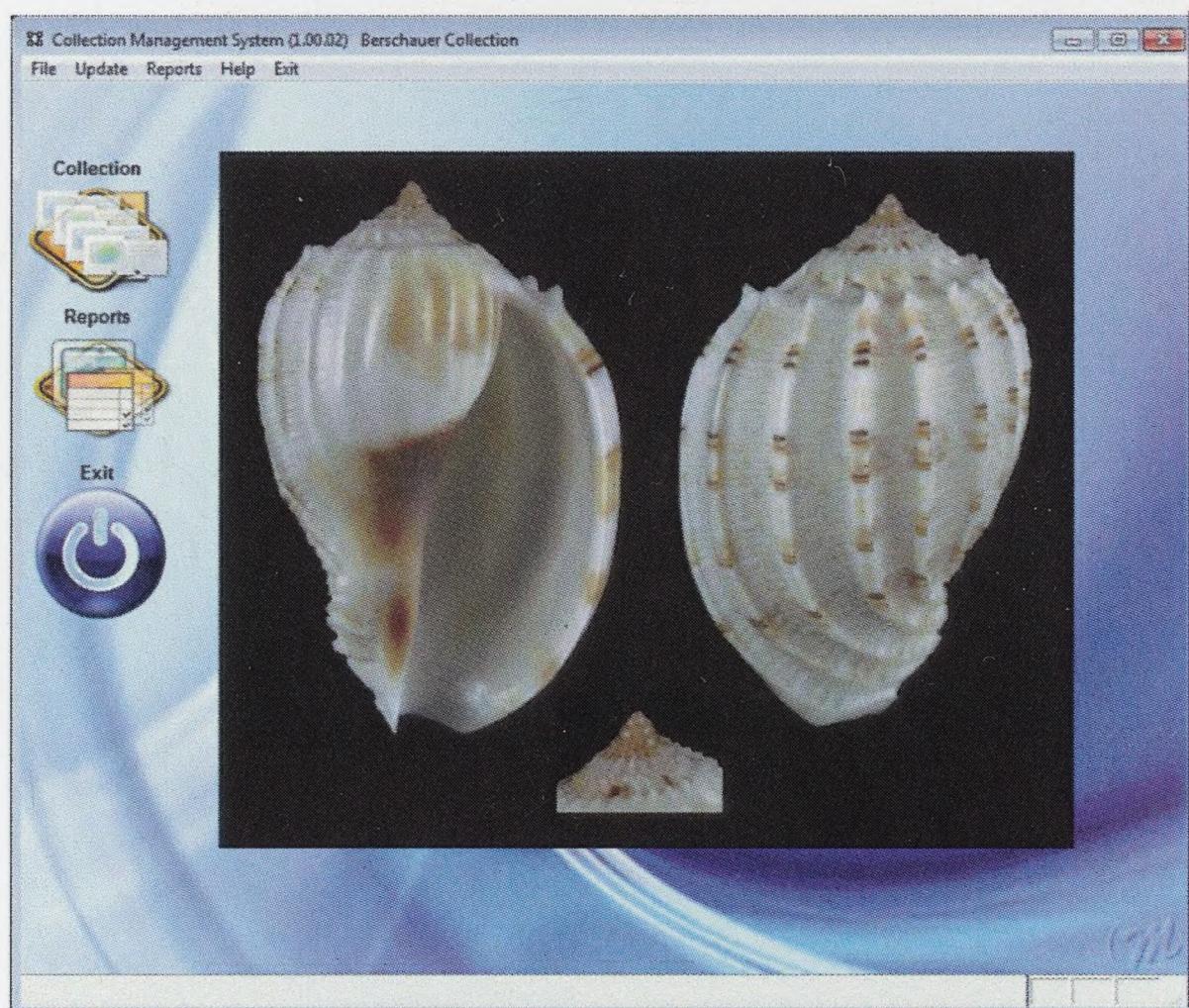
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